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Vol. XIX, Pt. VI, p. 616, line 15, *substitute* " fertile " *for* " sterile."

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Vol. XX, Part I January, 1925

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ORIGINAL ARTICLES

THE IMPERIAL MYCOLOGICAL CONFERENCE.*

BY

F. J. F. SHAW, D.Sc., A.R.C.S., F.L.S.,

Offg. Imperial Economic Botanist.

The First Conference of Empire Mycologists was held in the Imperial College of Science, London, during July 1924 and was largely attended by Mycologists from all parts of the Empire.

The conference was opened on 2nd July by Earl Buxton who in his opening address drew attention to the fact that for the progress of the tropical Dependencies of the Empire the fight against diseases of plants is scarcely less important than that against human diseases, while in the Dominions there was abundant evidence that the importance of the subject was more vividly realized than at home owing to the magnitude of their agricultural interests. The meeting then proceeded to discuss the *organization and activities of the Bureau of Mycology.* This subject was referred to a special committee of the conference. The committee examined and approved of a scheme for increasing the staff of the bureau and, as this scheme involved an increased expenditure of £1,500, recommended that an appeal should be made to the Governments of the Dominions, India, the Sudan, and the Colonies and Protectorates to provide the sum required. The recommendations of the committee were unanimously accepted by the conference.

At the second session the subject before the meeting was the *co-ordination of the investigation of fungicides.* Mr. Tattersfield (Rothamsted) in opening the discussion said that present explanations of fungicidal action were inadequate. The correlation of chemical constitution with toxicity was difficult and the best method of ascertaining this correlation would be to determine the toxic effect of certain compounds and then to see what changes in this toxicity were brought about by the introduction of new groups into the molecule. The toxic action of substances on fungi might best be studied in the vapour phase and the methods employed by

* The present account has been compiled from the official minutes of the conference which the writer attended as a representative for India.

Schafer might well be followed in fungicidal work. The liquid phase was complicated by such phenomena as absorption, wetting and adhesiveness—a substance might be highly toxic to an insect in the vapour phase but quite innocuous as a liquid. The methods to be adopted in any investigation should be carefully scrutinized in view of the variant factors such as temperature, age, acidity and the like, which might be introduced. Comparisons were easier if a 50 per cent. death point were aimed at, a fact which was demonstrated by graphs. Dr. Brierley (Rothamsted) spoke of the empirical nature of the work done on fungicides and urged the necessity for the standardization of the physical conditions of experiment, and of the organism as far as possible. Mr. Dowson mentioned his experience in East Africa in spraying against coffee leaf disease (*Hemileia vastatrix*). Owing to the accidental failure of the supply of lime, Bordeaux mixture was prepared with calcium carbide.* A fluid containing a black precipitate which did not settle was obtained, and this fluid gave a very adhesive and efficient spray deposit. After some further discussion it was decided that the Governing Body of the Imperial Bureau of Mycology be moved to appoint a sub-committee to deal with this subject.

Dr. Butler then opened the discussion on *plant disease surveys in the British Empire.* He said that in new outbreaks of disease it was most important to ascertain whether the parasite was a new introduction or not, as in the latter case the virulence of the epidemic was likely to be due to temporary circumstances and might be expected to pass when conditions became normal. The outbreak of *Diplodia Corchori* amongst jute in India was a striking example of this kind and reference was also made to the present epidemic of wither-tip of limes in Dominica. The powers of dissemination of parasites can often be ascertained from disease surveys and such information was of the greatest assistance in framing schedules for plant quarantine. Mr. Cotton (Kew) described the history of the survey of England and Wales and emphasized its importance in estimating losses from disease in legislating and in replying to queries from foreign countries. Dr. Shaw (India) stated that in 1922 a list of all the specimens in the Pusa Herbarium was published. A smut disease of mustard had appeared in India and it was very useful to them to be informed by the Imperial Bureau of Mycology that the disease had only previously been recorded from Denmark. Recently in India the schedule of prohibited plant imports had been revised, particularly in respect of Fiji disease of sugarcane, and it became of the utmost importance to know accurately the present distribution of this disease.

The first subject before the meeting at the third session was *the standardization of popular and scientific nomenclature in plant pathology.* Mr. Cunningham (New Zealand) in opening the discussion said that diseases must have popular names and confusion must result if these were not standardized. There was also some

* Calcium carbide 12 oz., copper sulphate 2 lb., and water 50 gallons.

considerable divergence of usage in scientific nomenclature and, until some standard basis for the distinguishing of species from one another was adopted, there was bound to be constant difficulty. He held the view that species should only be separable on morphological grounds. Mr. Cotton stated that the Pathological Committee of the British Mycological Society had undertaken the task of standardizing the common names of diseases in England and Wales. The most important principles were that the name adopted should be one in common use and should as far as possible describe the disease. Further discussion showed that the conference felt that there would be considerable difficulty in inducing the present generation of farmers to adopt standard names for diseases of crops.

The next subject was *the encouragement of industrial enterprise in the investigation of plant diseases*. Mr. Tunstall (Indian Tea Association) described the history of the scientific department of the Indian Tea Association, which, except for a small Government grant, was supported entirely by the tea industry. Dr. Butler stated that in his tour round the world he had been much impressed by the work being done by private enterprise. The Hawaiian Sugar Station cost £40,000 a year, but the growers were well satisfied with the results and the control of sugarcane diseases in Hawaii was scarcely equalled elsewhere, except, perhaps, by the Colonial Sugar Refining Co., which operated in Fiji, New South Wales and Queensland, and maintained a highly competent scientific staff. Colonel French (Empire Cotton Growers Corporation) stated that the funds of his Corporation were being utilized : (1) to send students to the Colonies to grow cotton ; (2) to encourage research by grants to research institutes and schools of agriculture ; (3) to send out experts to assist local departments of agriculture. The discussion terminated with the consideration of a proposal from the Government of Zanzibar that phytopathological officers might be trained to deal with both insects and fungi. A very definite opinion was unanimously expressed by the conference that such a course was unadvisable.

At the fourth session Dr. Doidge (South Africa) opened the discussion on *diseases of tropical plantation crops* with an account of the campaign against citrus canker (*Pseudomonas citri*) in South Africa. The disease was first noticed in 1908 and spread with amazing rapidity. The condition of affairs indicated that the only course to prevent the ruin of the citrus industry was to attempt the eradication of the disease by the destruction of all infected trees. The cost of the campaign to date had been £117,000 but it was now over two years since the last case was seen, and although the organism was known to be capable of living for a long time, the present position gave grounds for hoping that the disease had been exterminated. The next wet season would be decisive. Dr. Butler pointed out that if the ultimate result of these operations bore out the present hopes this would he thought be the first case of the total eradication of a disease.

Mr. Massey (Sudan) then gave an account of the diseases of cotton in the Sudan. The present outbreak of angular leafspot (*Bacterium malvaccarum*) was described. The organism was readily isolated and inoculations proved its pathogenicity. It

was always accompanied by a yellow coccus which, however, was not pathogenic. The disease appeared immediately after germination in the seed-beds and the effect of humidity and temperature on its course was discussed, detailed data being presented to illustrate this effect. With regard to the question of control, it could be definitely said that the disease was carried over on the seed and the problem was one of seed disinfection. Disinfectants gave healthy plants but subsequent infection occurred, contact being sufficient to bring this about. The organism was unable to survive in the soil and was very susceptible to heat and light in the laboratory. Manure had no effect on the disease. Other allied plants in the Sudan did not become infected, though he had recently heard of a case of the sort in America. Several disinfectants had been tried, including uspulin, mercuric chloride, "sporocide," lysol, and Jeyes fluid. There was less fuzz on Egyptian cotton seed than on American and, hence, treatment with concentrated sulphuric acid was unnecessary. Lysol and the cresol disinfectants with resin soap gave more efficient wetting and in the present year the whole of the seed of the cotton crop was being disinfected with cresol disinfectants. The ideal treatment would deal with the pink bollworm, simultaneously with the angular leafspot organism and the recent work of disinfection of cotton seed by heating to 100° C. *in vacuo* might prove useful. Other diseases of cotton in the Sudan were briefly described, including an obscure disease, which is suspected to be due to *Rhizoctonia*.

Mr. Britton-Jones (formerly Ministry of Agriculture, Egypt) spoke of a root rot caused by a species of *Rhizoctonia* identical with the fungus hitherto called *Sclerotium bataticola*; this disease and wilt disease both caused a certain amount of loss in Egypt. Dr. Shaw mentioned that researches now being carried out in India by Mr. Dastur indicate that wilted plants contain a higher proportion of aluminium than healthy plants and point to the toxic effect of aluminium as the primary cause of cotton wilt, fungi being possibly secondary agents. Mr. Summers (Shirley Institute) brought forward the subject of the mildewing of cotton fabrics, one which he stated was of vital importance to the cotton industry. The fungi causing these troubles seemed to be usually tropical moulds and the importance to cotton growers of growing clean cotton was emphasized, as in future the cotton spinners would not be inclined to buy cotton which had a reputation of being contaminated. Any fungus which had the power of lowering the p^H value had the power of spotting fabrics, while fungi which raised the p^H did not produce such striking symptoms but had a tendering action. Disinfection with ammonium silicofluoride and steeping with formalin had been tried.

Prof. Ashby (Trinidad) gave an account of the "Panama" disease of bananas. A toxin produced by the fungus (*Fusarium cubense*) probably played a large part in causing the characteristic symptoms of the disease. The spread of the disease was chiefly by the planting of infected rhizomes; the organism could persist in the soil for at least ten years. The disease had been kept under control in Jamaica but the real solution of the problem was the discovery of an immune variety.

Mr. Bunting (Gold Coast) spoke of the diseases of cacao in the Gold Coast. Of these, one of the most important was caused by a new fungus, *Trachysphæra fructigena.* Other diseases were "collar crack" (*Armillaria mellea*) and the common parasite *Phytophthora faberi.*

The conference then proceeded to discuss the *influence of soil conditions on plant diseases.* Mr. Nowell (Trinidad) in opening the discussion expressed the view that many of the diseases of plants were due primarily to bad soil conditions and that the fungus was only parasitic when these conditions rendered the host susceptible. Diseases of this nature could be divided into two groups : (*a*) root diseases and (*b*) debility or poverty diseases. Root diseases might be occasioned by over-richness in the soil ; in the central portions of Dominica limes were grown in pockets of exceptionally rich soil, and in these places the lime is particularly susceptible to root disease associated with *Rosellinia.* On the other hand, rich soil might induce resistance in certain instances. Thus the cultivation of the Bourbon cane was rendered impossible throughout most of the West Indies by *Colletotrichum falcatum,* but in certain areas of rich soil in Trinidad this variety was still cultivated. Red ring, a nematode disease of the coconut, was mentioned as a type of disease apparently uninfluenced by soil conditions. With regard to debility diseases, these were largely occasioned by poverty of the soil. The root rot of sugarcane has been attributed to various organisms such as *Marasmius, Rhizoctonia, Odontia* and *Pythium,* but the speaker thought it was really due to failure to provide the cane with conditions suitable for the growth, the habitual presence of fungi being a consequence of a primary weakness in the plant. Poverty of soil was one of the causes of this weakness, and by good manuring the disease could often be completely overcome. Other unsuitable soil conditions could induce the disease ; thus, by applying ammonium sulphate in excessive quantity so that the soil becomes acid, an outbreak of *Marasmius sacchari* was usually induced. Potash deficiency in cotton leads to a disease known as yellow leaf blight, the leaves showing a peculiar yellowing and later becoming attacked by the weakly parasitic fungi, *Alternaria, Macrosporium* and *Cercospora.* Chlorosis of sugarcane occurred in patches of soil containing excessive amounts of saltpetre. "Blight" of sugarcane was really due to a soil factor, although insect attack was the immediately exciting cause.

Mr. Tunstall said that many of the diseases of tea could be controlled by soil treatment and cultivation. Brown blight (*Glomerella cingulata*), grey blight (*Pestalozzia Theæ*) and red rust (*Cephaleurus mycoidea*) were associated with a deficiency of potash. The disease caused by *Botryodiplodia theobromæ* could be cured by applications of potassium nitrate and examination of the plants after this treatment showed that the hyphæ of the fungus were absorbed by the host. Dr. Rayner pointed out the importance of mycorrhiza in relation to diseases which were influenced by soil conditions.

The subject before the conference at the last session was *the application of the results of mycological investigation.* Dr. Shaw opened the discussion from the point

of view of a tropical country with illiterate cultivators. He described the organization of the Agricultural Service in India and t e methods adopted in the control of bud rot of palms, "black band" disease of jute, smut of sorghum, red rot of sugarcane and *Phytophthora* rot of arcca palm. Dr. Murphy (Irish Free State) then dealt with the subject from the point of view of temperate countries with a more highly educated proletariat. He considered that there should be in phytopathology, as in medicine, a division of labour between the adviser, who is primarily concerned with the introduction of new methods of disease control, and the specialist, who investigates fresh problems. Any methods of control must be simple if it was to succeed in the hands of the agriculturist.

The scientific discussions now terminated and the following resolutions were unanimously adopted by the conference :—

1. That specimens of the diseases of plants in the different parts of the Empire be sent to the Bureau in sufficient quantity to enable sets of typical specimens to be prepared for distribution to institutions or individuals interested in the study of plant diseases throughout the Empire.

2. That lists of determinations of fungi sent in for naming should be published in leaflet form and distributed from time to time with the *Review*, the name of the sender and locality being indicated in each case.

3. That the Bureau should undertake at an early date the publication of a pamphlet containing the names and addresses of mycologists and plant pathologists in the British Empire, together with an indication of their special interests. This pamphlet should be brought up to date, say, every two years.

4. That copies of index cards dealing with the diseases of such crops as are indexed at the Bureau should be prepared on request and sold to the Government mycologists of contributing Dominions and Colonies at cost price.

5. That, in view of the benefits derived from an exchange of views between overseas mycologists, conferences similar to the present one should be held every five years.

6. That the proposal that the conference should consider the question of the interchange of investigators at certain centres throughout the Empire for periods such as six or twelve months be referred to the Imperial Botanical Conference.

7. That an annual report showing the contributions for the upkeep of the Bureau made by each contributing Government be circulated to the latter.

8. That the question of the formation of a body or sub-committee for the co-ordination of investigations of fungicides be brought before the Managing Committee of the Imperial Bureau of Mycology with the request that they take such steps as they deem fit.

9. That, while the training of mycologists should include a thorough grounding in the requisite sciences, mycologists should not be required to undertake the duties of entomologists in Government Departments of Agriculture.

10. That the proposals of the committee appointed by the conference to consider proposals for the future work of the Bureau and their cost be accepted as representing the requirements for the efficient carrying on of the work of the Bureau for the next five years, and that steps be taken to secure the annual income of £6,500 necessary to give effect to them.

11. That this conference is of the opinion that the financial portions of the report of the above committee be specially commended for the favourable consideration of the Managing Committee of the Bureau.

12. That this conference is of opinion that an urgent need exists for the provision of more adequate accommodation for the Bureau.

13. That this conference expresses its appreciation of the service rendered by the *Review of Applied Mycology* to all workers on the subject, especially those ~~in~~ overseas Dominions and Colonies, and is of the opinion that one of its most useful features is the length of the abstracts and would regret any curtailment in this respect.

14. That this conference of overseas mycologists desires to place on record its appreciation of the work which has been carried out by the Imperial Bureau of Mycology, and expresses the hope that this work will be extended when funds permit.

The members of the conference with few exceptions attended the Imperial Botanical Conference, which was held in the succeeding week, and at which considerable attention was given to economic mycology. The Ministry of Agriculture and Fisheries also issued invitations to all members of the Mycological Conference to attend a conference on the important question of legislation regulating the import of plants and plant products with a view to preventing the introduction of plant diseases. The discussions and excursions at these conferences covered a very wide field and materially assisted in making this first meeting of Empire mycologists a success. In addition to the formal meetings two excursions were arranged during the mycological conference, one to the Imperial Bureau of Mycology and one to the plant diseases exhibit in the Tropical Health Section of the British Empire Exhibition. At the latter a very striking and representative collection of plant diseases, to which mycological workers in India had largely contributed, was being exhibited to the public.

SOME FACTORS AFFECTING NITROGEN CHANGES IN BLACK COTTON SOIL.*

2. THE INFLUENCE OF MOISTURE CONTENT DURING THE RAINY SEASON ON THE AMMONIFYING AND NITRIFYING POWER OF BLACK COTTON SOIL.[1]

BY

F. J. PLYMEN

AND

D. V. BAL,

Department of Agriculture, Central Provinces and Berar.

Black cotton soil is primarily a *kharif* (monsoon) crop soil and the conditions controlling crop growth are largely the result of changes in the moisture content of the soil. A *kharif* crop such as cotton, *juar* (sorghum) or *til* (sesamum) has a relatively short growing season. The seed is put into the soil just when a long dry, hot period has been followed by a little rain. The seed germinates and the moist heat of the monsoon months produces or should produce rapid growth. It is not unusual, however, to find a field of *juar* water-logged and giving every appearance of nitrogen starvation, while the frequent response of cotton to a small dressing of nitrate shows that, under some circumstances, soluble nitrogen is in defect. The regular supply of soluble nitrogen to a growing *kharif* crop is, therefore, a matter of some importance, and it appears desirable to know how the natural supply of soluble nitrogen in the soil is controlled and affected by the intensity of the rainfall.

Most of the determinations made upon nitrates in Indian soils are concerned only with the supply of nitrate to cold weather (*rabi*) crops.[2]

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* Paper read at the Agricultural Section of the Indian Science Congress, Bangalore, 1924.

[1] For No. 1 of this series entitled "The biological determination of the relative availability of different nitrogenous organic manures in black cotton soil" see *Agri. Jour. India*, 1919, Vol. XIV, p. 414.

[2] Leather, J. W. *Mem. Dept. Agri. India, Chem. Ser.*, Vol. II, pp. 63-140.

Clarke, G. *Agri, Jour. India*, 1922, Vol. XVII, pp. 463-475.

The observations thus recorded deal largely with nitrate accumulation, whereas the enquiry now under discussion was concerned with ammonification and nitrification in a soil carrying a *kharif* crop during the wet season.

Experimental.

The soil employed for these determinations was taken from a field always put under *kharif* crops such as cotton and *juar*. This soil is the common type of ordinary black cotton soil as found over large areas in the Central Provinces and Berar and many parts of the Deccan. The physical analysis of this soil has been given in a previous paper.[1] It is sufficient here to note that being a *kharif* field the soil from it is only moderately heavy. Samples of soil were taken to a depth of 8 inches every ten days commencing from the 5th of May to the 15th of December. The sampling of a clay soil during the monsoon is not an easy process. It is impossible to use a boring implement and go down into the sub-soil to any depth. For this reason only surface samples to 8 inches could be taken. This was carried out by inverting a metal box over the soil, pressing the box down to the required depth and then digging the whole out bodily. In these samples, determinations were made of moisture, nitrite and nitrate. The soils, as collected, were used for determining their ammonifying and nitrifying powers.

The sample was immediately brought to the laboratory and thoroughly mixed. A quantity of about 100 grm. was kept in a weighed basin and dried at a temperature of 100 to 105° C.

The amounts of nitrite and nitrate present in the soil of each sample were estimated by the usual Griess-Ilosvay and phenol-sulphonic acid methods respectively.

500 grm. soil from the well mixed sample were taken and oil-free sesamum cake supplying 60 mg. nitrogen per 100 grm. of the sample was mixed with it and the whole placed in a glass jar lightly covered. The jars were incubated at a temperature of 30—33° C. for a period of 8 weeks. Determinations of ammonia, nitrites and nitrates were made every 15 days, the ammonia being liberated by boiling with recently ignited magnesium oxide.

Data presented.

The amount of moisture and oxidized nitrogen in the soil at the time of sampling, and the amount of nitrogen ammonified and nitrified are given in Table I.

The figures show not only the easily available nitrogen present in the soil at the time the sample was taken but also the capacity of the soil, with water content as found in the field, to decompose any further nitrogenous matter which may be added

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[1] *Agri. Jour. Ind.*, Sp. Ind. Sci. Con. No. 1919, p. 416.

TABLE I.

Showing the amount of moisture and oxidized nitrogen in the soil at the time of taking samples and the amount of nitrogen ammonified and nitrified (nitrified nitrogen includes both nitrites and nitrates).

Date	ORIGINAL SAMPLE				PER CENT. ADDED NITROGEN							
					AFTER 2 WEEKS		AFTER 4 WEEKS		AFTER 6 WEEKS		AFTER 8 WEEKS	
	No. of sample	Per cent. moisture	Nitrite N mg. per 100 grm. soil	Nitrate N mg. per 100 grm. soil	Ammonified	Nitrified	Ammonified	Nitrified	Ammonified	Nitrified	Ammonified	Nitrified
17th May	1	11 4	0 53	0 32	4·6	nil	2 8	nil	1 8	nil	0 0	nil
25th May	2	20 9	0 64	0 64	24 2	4 9	18 6	9·7	37·3	15 7	37 3	18·4
4th June	3	17 4	0 43	1 15	14·0	2 9	31 7	3 4	42 0	3 4	43 8	4·1
14th June	4	23 8	nil	1 28	28 0	19 8	9 3	34 5	2 8	85 4	1·8	85 4
24th June	5	19 4	traces	0 64	26 1	3 4	31 7	6 4	29 8	8 5	14·9	9 8
4th July	6	31 7	nil	traces	4 6	47 4	7 6	59·7	1 8	78 9	1 8	93 0
14th July	7	27·6	traces	0 51	18 6	42 8	7·4	56·3	1 8	81 4	1 8	96 0
25th July	8	32 3	nil	nil	18 6	51 0	3·7	81 3	2 8	76 0	0·9	85 4
4th August	9	21 6	..	nil	18 6	53 9	4 6	64 0	2 8	72·6	1 8	81·13
14th August	10	32 5	traces	traces	16 8	60·63	1·8	68 3	2 8	81·13	1 8	85 4
24th August	11	38·0	nil	nil	3 73	35 35	9 3	43 25	4 66	59·76	..	59 76
3rd September	12	36 4	nil	nil	9 30	41 70	1 86	76 85	..	76 85	1 86	81·13
14th September	13	43·7	nil	nil	4·66	21 98	..	32 89	..	34 16	..	32 02
24th September	14	37·0	traces	traces	13·06	15 35	..	54·02	..	64·0	..	76·80
3rd October	15	33·7	traces	traces	..	41·08	..	77·0	..	76·85	..	72·58
13th October	16	32·0	nil	nil	..	54 06	..	64 45	.	72·6	..	81·13
3rd November	17	26·0	nil	nil	21 3	29 86	3 7	43 2	1·8	59·76	1 8	72 5
11th November	18	22·0	..	..	32 6	2·1	28·0	4 26	..	..	28·0	7 4
24th November	19	19·8	nil	nil	3·73	2 1	..	..	..	..	18·6	4·26
4th December	20	17·1	nil	nil	1·86	nil	..	..	..		9 3	nil
15th December	21	13·0	..	..	..	..	..	..	..	..	..	nil

to it. This capacity for decomposing nitrogenous matter may show itself almost immediately or it may not be of any great intensity even after a fairly prolonged period. For this reason the amount of ammonified and nitrified nitrogen formed in the soil was determined at intervals of two weeks.

The observations cover a complete period of the monsoon from before the first rain usually falls until a dry season is once more established. They also cover the

usual period of growth of a *kharif* crop from sowing time to harvest. The intensity of the rainfall and its distribution are shown in Fig. 1.

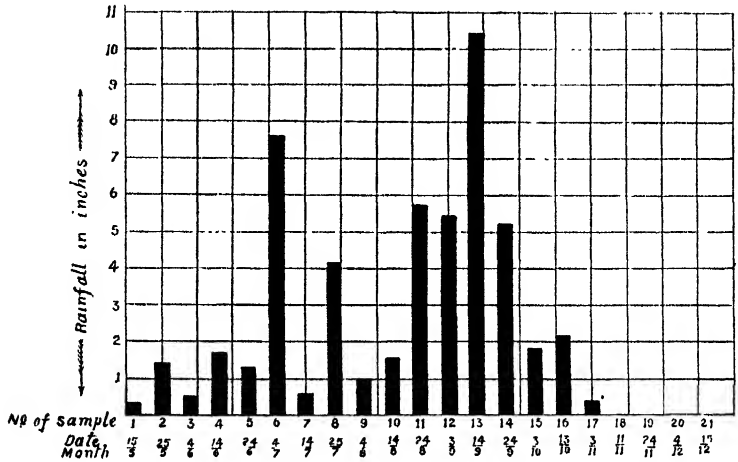

Fig. 1. Rainfall received during 10 days preceding the taking of sample.

Discussion of results.

It will be observed that, at the end of the hot weather just as the rainy season commences, the top layer of soil to a depth of 8 inches contained a little oxidized nitrogen both in the form of nitrite and nitrate. The disappearance of this oxidized nitrogen appears to have been almost simultaneous with the first heavy fall of rain, and it is interesting to observe that during the rest of the period over which the observations extended only slight traces of oxidized nitrogen were found again. This may have been due to the washing down of the nitrite and nitrate by the heavy rain and to the absorption of these substances by the growing crop. From the end of July to the early part of September the soil was in a wet condition containing at one time upwards of 42 per cent. of moisture. Even, however, when more moderate moisture conditions re-established themselves, the soil *in situ* showed no oxidized nitrogen.

The biological activity of the soil presents a number of interesting points, and in this connection it must be remembered that the activity of the soil in modifying the condition of nitrogenous compounds was determined on the soil as it was taken from the field and with the amount of moisture actually therein at the time. In its dry state in the month of May, the soil had no power to produce either ammonia or nitrified nitrog n, the formation of nitrified nitrogen being obviously controlled by the production of ammonified nitrogen. So long as the soil had a moisture content of less than about 23 per cent. it showed no great capacity for breaking down

organic nitrogenous compounds. With from about 24 to 36 per cent. of moisture this soil seems to attain its maximum biological activity, and this activity is of a fairly high order as from 50 to 60 per cent. of added organic nitrogen was oxidized within the short period of two weeks. These observations illustrate what the biological activity of a soil can be under suitable conditions of temperature and moisture content. It should be noted that at this time of year the shade temperature during the twenty-four hours fluctuates between 75° and 90° F.

With a moisture content of about 40 per cent. this soil deteriorates in nitrifying power, showing that the optimum moisture content for nitrification has been passed. With the natural advance of the season the soil gradually dries out and the biological activity of the soil diminishes with the reduction in water content.

Fig. 2 shows the variations in the water content and the total nitrate produced in the soil in a period of 8 weeks.

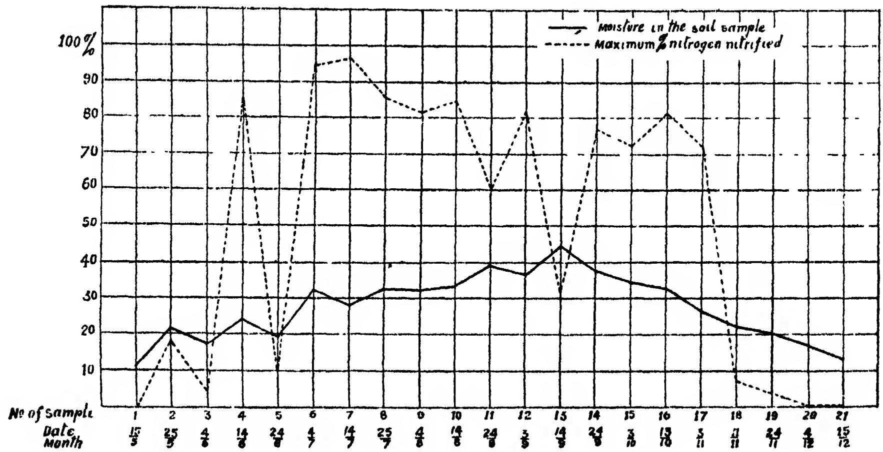

Fig 2. Variations in the moisture content of the soil at different periods and the maximum per cent. added nitrogen nitrified in eight weeks.

From these observations it is apparent that black cotton sôil, under the climatic conditions described above, only shows any considerable bacteriological activity during four months of the year.

The importance of good drainage in a cotton field is also emphasized. Much of the land used for cotton production is often badly water-logged and retains a high proportion of water for a long period. This excess of water is seen, from the data now put forward, to result in checking the production of plant food and consequently in preventing plant growth. The value of a slight dressing of nitrate which has been found in practice to be very beneficial to cotton during the growing

season is doubtless due to its supplying readily available nitrogen at a critical time when the biological activities of the soil are temporarily suspended.

The authors would emphasize the necessity for distinguishing between nitrate accumulation in a soil and the nitrifying power of the soil. The figures given above show that it is possible to have a soil containing very little nitrified nitrogen in it and yet to possess a considerable capacity to produce that form of nitrogenous compound. The actual nitrified nitrogen accumulated in a soil depends upon a number of factors such as absorption of nitrate by the plant and movement of the soil water. The two factors, aeration of the soil and water supply, appear to be of the main importance in promoting nitrification in black cotton soil, the temperature of the soil being generally sufficiently high to encourage the process. Nitrification is a form of oxidation which is affected by the moisture conditions prevailing in the medium in which it occurs. The authors would, therefore, point out the desirability of always recording the water content of a soil upon which nitrification determinations are made.

The observations discussed above were made upon the soil as found in the field at regular intervals during the monsoon period. Further experiments, however, were conducted upon air-dry soil to which definite proportions of water had been added and worked into the soil by hand. The moisture content was fixed at a certain fraction of the maximum water capacity of the soil which is about 60 per cent. by weight as determined by Hilgard's method in a layer 1 cm. in depth.

From the figures given in Table II (Nos. 1–4) it will be seen that the results

TABLE II.

Showing nitrification in air-dry black cotton soil moistened to different degrees of saturation.

No.	Degree of saturation	Per cent. moisture	PER CENT. ADDED NITROGEN							
			AFTER 2 WEEKS		AFTER 4 WEEKS		AFTER 6 WEEKS		AFTER 8 WEEKS	
			Ammonified	Nitrified	Ammonified	Nitrified	Ammonified	Nitrified	Ammonified	Nitrified
1	¼ .	15	20·5	nil	27·1	nil	21·5	traces	..	traces
2	⅓ .	20	28·0	nil	25·2	2·5	21·5	13·0	..	19·7
3	⅜ .	22·5	31·7	1·5	27·1	8·2	7·5	64·0	..	68·3
4	½ .	30	36·4	1·9	20·5	43·4	1·8	78·85	..	89·6
5*	½ .	30	28·0	18·4	4·6	62·9	0·9	85·4	..	93·9

NOTE—Nitrified nitrogen includes both nitrite and nitrate nitrogen.
* The water was allowed to diffuse into the soil without mixing by hand.

obtained with artificially watered soils agree in general very closely with observations made on soils taken direct from the field. With a water content of 15 per cent. very little nitrification takes place. At 20 per cent. a slight action takes place within a period of 8 weeks. With a moisture percentage of from 22·5 to 30 per cent. nitrification is distinctly more vigorous. The chief point of difference between the artificially and naturally watered soils is that nitrification appears to be slow in starting in the former case even with a suitable soil moisture content. To suddenly give an air-dry soil a water content of 30 per cent. does not result in raising the soil's nitrifying capacity to the same extent as if the soil receives natural rainfall and gradually attains a 30 per cent. water content. In this connection figures for samples 6, 7, 8 and 9 of Table I and sample 4 of Table II can be compared. The amount of nitrification produced by these soils at the end of 8 weeks is approximately the same, but soils which have been receiving rain for some time can start their nitrifying action much quicker than air-dried soil brought at once to a 30 per cent. moisture content.

The question of tilth must also be considered. A heavy clay soil when mixed with water by hand assumes a lumpy form very different in tilth to that of a soil containing the same amount of water in the field. To dètermine the effect of the texture of the soil upon its nitrifying power an experiment was made in which 30 per cent. of water was allowed to diffuse into the soil without mixing by hand. The results obtained are shown in sample 5 of Table II. By comparing the figures for samples 4 and 5 in this Table it will be observed that the puddling effect produced by hand mixing delays the start of nitrification but that this delay is eventually made good.

SUMMARY.

(1) The effect of the rainfall during the monsoon upon the oxidized nitrogen of black cotton soil has been studied.

(2) Figures are given showing the relation between the moisture content of the soil *in situ* and the nitrifying power of the soil.

(3) A moisture content of from 24 to 30 per cent. appears to enable black cotton soil to attain its maximum biological activity as regards nitrification.

(4) This activity is of a fairly high order as under the moisture conditions above stated and at the temperature prevailing during the monsoon months 50 to 60 per cent. of added organic nitrogen is oxidized in two weeks.

(5) Under the climatic conditions described in the paper, black cotton soil only shows any considerable bacteriological activity during the months from approximately mid-June to mid-October.

(6) Laboratory experiments in which definite quantities of water were mixed with air-dry black cotton soil agree with observations made on soil taken direct from the field.

(7) Nitrification in artificially watered soils previously air-dried is slower in starting than with soils receiving a natural rainfall, but the nitrifying efficiency after a period of 8 weeks is about the same.

(8) A heavy clay soil which had lost its texture showed at first a diminished nitrifying power when compared with the same soil in good condition.

RESEARCH WORK ON ANIMAL NUTRITION IN INDIA.*

BY

P. E. LANDER, M.A., D.Sc., A.I.C.,

Agricultural Chemist to the Government of the Punjab.

It is a slogan of popular speech often heard that agriculture is the main occupation of the vast majority of the people of India, and the very life breath on which the economic prosperity of the country depends. It has been the staple industry of the country from time immemorial, and will, as far as one can judge, continue to be so, as India is an essentially agricultural country.

Very different is the story of the history of agricultural research, which is but in its early infancy, and whose chances of arriving at a healthy adolescence depend on the framing of liberal and systematic lines of enquiry, based upon the latest methods of scientific knowledge, and carried out by workers who can bring these methods to bear on the several branches of research into which the subject inevitably divides.

The *raison d'être* of research is primarily to increase the total food supply of the people both for their own personal consumption and for export in exchange for manufactured goods, and all branches of the subject which conduce to this end must be considered of equal importance. The particular branch of this research with which I at present propose to deal is that of animal nutrition. It needs no stretch of the imagination to realize that the cattle of India form the very foundation-stone so to speak of the country's agricultural activities, not only as draught animals, but as sources of food, and in particular, milk, and any research which aims at increasing the economic production both of work and of food must be of fundamental importance.

Although the history of agricultural research in general in India is a short one, it must be conceded that specialized research on animal nutrition is shorter. still, in fact until quite recently, practically non-existent.

In 1921, at a meeting of agricultural chemists and bacteriologists held at Pusa, Mr. Warth introduced the subject of the food values of Indian foodstuffs, on which a general discussion followed and a resolution was passed that work should be pursued on general lines, and not be restricted to too narrow a field. Up to this

* Paper read at the Agricultural Section of the Indian Science Congress, Bangalore, 1924.

time no work, except isolated analyses, had been carried out in India, and this may mark the beginning of a systematic attempt to attack the problems of animal nutrition in India.

We have here a virgin field in which the only work done up to this time was some analytical investigations on foodstuffs mainly carried out by Dr. Leather. With the establishment of an Imperial Department for the carrying out of animal nutrition work, and with a keen interest displayed in one or two of the provinces, it would appear that the time has arrived for laying down a policy or programme of research and carrying it out in as systematic and comprehensive a manner as possible.

With this end then in view, I wish to point out what I consider are the basal lines along which the problem should be pursued, and to indicate the nature of the work which has already been started at Lyallpur during the last two years, and to plead for co-operation and collaboration between those who have made this work their particular study.

If we would glance for a moment at the institutions in such countries as England, America or Denmark, and note the intensity and nature of the research work carried on there, we shall gain some insight as to the possible lines of enquiry which might profitably be pursued in India. Every country has its own peculiarities and characteristics, and results and conclusions arrived at, say, in America on animal nutrition problems, need not necessarily hold good in India. The composition of a particular fodder common to both countries may be quite different in each, as may also be its nutritive value in the animal metabolism. Each country therefore, whilst adhering to general principles, must work out its own salvation in regard to details, a principle which holds good in research no less than in politics.

In a recent paper[1] on some digestibility trials carried out at Lyallpur in the winters of 1921 and 1922, I ventured to indicate three main lines of study on animal foodstuffs with their attendant problems although from each of these many others may branch out.

The first I call the crude routine analyses as carried out in the laboratory, and which, with a standardized process of procedure, should present no difficulty to the average laboratory worker. This in itself opens out many lines of enquiry. I have noted, for example, that the *bhusa* obtained from one year's harvest in the Punjab contains twice as much protein as *bhusa* from the previous year's harvest, and in framing any system of rations such divergencies in food values must be taken into consideration. There are undoubtedly many factors at present undefined which may influence the food value as revealed by chemical investigation, such as manuring, type of soil, water supply, climate, etc., to mention but a few, and it is highly necessary to accumulate all the data we can bearing on the variations of the nutrient materials in Indian foodstuffs.

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[1] *Mem. Dept. Agri. India, Chem Ser.*, Vol. VII, No. 4, 1924.

The next line of enquiry I suggest follows logically from the first, and is the establishment of economic standard maintenance rations with systematically conducted digestion trials on a large number of suitable animals.

Food values as revealed by chemical analyses are not of necessity any criterion as to their actual value when fed to animals. Ingredients may be present in considerable quantities and yet not be capable of being fully utilized by the animal in the course of digestion. It is thus not so much the actual quantities of fats, carbohydrates, proteins, etc., which a feeding stuff may contain, but the quantities of these which the animal can actually utilize. We have in this connection to determine what are the most economical combinations of feeding materials to supply to our animals. An interesting illustration on this point was recently afforded me whilst working on the digestibility of fresh *shisham* (*Dalbergia sissoo*) leaves as a reserve fodder supply. Although chemical analysis revealed the leaves to be comparable with green oats in nutritive ingredients, yet the animals could not tolerate more than a very small daily ration, most likely due to the presence of some astringent principle which had a deleterious effect on the animal's digestive tract.

It is interesting to record that when the leaves were siloed, they preserved their main constituents practically unchanged, and the animals were able to be fed the material in considerable quantity. Dairy cows are also being fed on the siloed material, and the results will be published when ready.

Such trials as these are an absolutely necessary adjunct to ordinary chemical analysis for the determination of food values, and it is well to realize at the outset the comprehensive nature of work of this kind if properly carried out. A well-known American authority, Armsby, has recorded how, during some digestion trials carried out over several months, seven experts were continuously employed quite apart from the attendants looking after the general welfare of the animals. It is also necessary to emphasize the necessity for using a large number of suitable animals, and for the daily accurate record of all data such as body-weights, etc.

The third line of enquiry I suggest is perhaps most difficult of all, and involves the chemical and biological investigation of the proteins, etc., present in a food-stuff, their efficiency or otherwise in amino-acid content and the framing of suitable diets based on such knowledge, and also their values as determined by experiments on young growing animals. To give only one example. The low efficiency of maize as the sole source of protein to promote growth and well-being in young animals is well known, owing to its protein, Zein, being deficient in certain amino acids essential for growth, and a wide field of research opens up in this hitherto but little explored region of protein values.

There is one further line of enquiry which may be mentioned here, *viz.*, the subject of accessory food substances, which have come into great prominence in recent years. Certain well defined facts have been established, but the field in India is practically unexplored. We know that certain diseases such as beri-beri

and scurvy are due to the absence from the diet of minute quantities of certain substances as yet unisolated and of unknown chemical composition. Pellagra is another case in point, being essentially a disease of poverty, which, in its early stages, yields fairly readily to dietetic treatment. Indeed it is being emphasized by physicians that without dietary measures there is no effective treatment, and numerous cases are recorded in which the disease has promptly disappeared when milk, eggs and meats, together with a liberal amount of the leafy vegetables such as cabbage and lettuce, were included in the diet.

It is not too much to expect that research directed along these lines of dietetic investigation would bring to light further interesting and valuable facts bearing on the relationship of diet and disease.

In conclusion, no discussion on the subject of animal nutrition would be complete without reference to the important subject of milk-production. Milk is a complete food in itself, and the sole food for most animals at the time of birth, and there is no subject worthy of more sustained attention on the part of all branches of the community than that of producing an adequate supply of pure and wholesome milk for the people. The eugenist is at work on the production of improved breeds of cattle suitable to the country, the biochemist should be at work in collaboration with him in determining how to obtain the most economical yield of the greatest quantity of milk of the highest possible quality. There can be no doubt that the people generally do not realize the importance of milk and other dairy products in the diet. There is no substitute for milk, and its use should be distinctly increased instead of diminished, regardless of cost, whilst every possible means should be employed to reduce the cost of production. The necessity for the liberal use of milk and its products both in the diets of children and adults should be emphasized. The value of milk as a food cannot be estimated solely on the basis of its content of protein and energy; even when measured by this standard it compares most favourably with other foods, but it has a value as a protective food in improving the quality of the diet, which can be estimated only in terms of health and efficiency, and the greatest stress should be laid on the importance to the population of India of increasing the quantity and quality of its milk supply.

In all the lines of enquiry mentioned it is very necessary to keep the economic factor well in mind, and, whilst not overlooking the facts which may be of purely academic interest, concentrate attention on the goal to be aimed at, *viz.*, the application of results into actual practice.

I have but briefly suggested the more important lines on which research work on animal nutrition might profitably be pursued in India, keeping in mind the particular requirements of the country. Once a start has been made, many other specific problems will present themselves, and intensive and sustained effort cannot fail to produce valuable results and justify itself.

INTENSIVE NITRIFYING BED AS A MEANS OF PREVENTING NITROGEN LOSSES FROM CATTLE URINE.*

BY

N. V. JOSHI, B.A., M.Sc., L.Ag.,

First Assistant to the Imperial Agricultural Bacteriologist.

In a previous paper[1] on "Studies in methods to prevent nitrogen losses from dung and urine during storage," the writer has drawn attention to the fact that urine loses a large percentage of its nitrogen if kept under aerobic conditions; and in case it is necessary to preserve the urine without loss of nitrogen it has to be kept anaerobically. Further it was found that a layer of some oil spread over the urine brings about the conditions necessary to preserve the urine for a long time involving practically no loss of nitrogen. The layer of oil effectively prevents evaporation which is chiefly responsible for the loss of nitrogen in urine under aerobic conditions by causing formation and volatilization of ammonia.

Now, if the losses in nitrogen are, as stated, chiefly due to evaporation of ammonium carbonate formed from urea and other compounds in urine, it was considered that it would be possible to prevent such losses if the urine could be subjected to the rapid action of nitrifying bacteria which would convert it into nitrates before any loss takes place. There would be no difficulty in quickly nitrifying the urine if its nitrogen content were smaller, or what is the same thing, if it were diluted with water. But being concentrated in nitrogen so much water would be required for its dilution before nitrification took place, that it would prove quite uneconomical in handling. The obvious way of overcoming the difficulty is to develop the capacity of the nitrifying organisms to deal with a concentrated nitrogenous material like the urine. Muntz and Laine[2] have developed a method by means of which the process of nitrification is made sufficiently energetic to deal with larger concentration of ammonium salts in solution which is passed successively over several peat beds. The organisms in the last peat bed are able to tolerate the presence of a higher concentration of ammoniacal salts and nitrates by getting accustomed in gradually increasing quantities of these substances from first bed to the last. The necessity of such gradual increase of concentration will be apparent when it is known that the presence of high amounts of ammoniacal salts or nitrates in initial stages of nitrification stops the further development of the nitrifying organisms and paralyses their activity. Since urine contains organic nitrogen, it is not enough

* Paper read at the Agricultural Section of the Indian Science Congress, Bangalore, 1924.

[1] Joshi, N. V. *Agri. Jour. India*, Vol. XVII, Pt. 4, July 1922.

[2] Muntz and Laine, *Annales de la Science Agronomique*, 3* Serie, 2, 1906.

for our purpose to develop organisms able to withstand higher concentration of ammoniacal salts alone, but it is necessary that nitrifying bacteria should continue their activity in the presence of higher amounts of organic nitrogen as well. In case this method proves successful urine will be required to pass over a bed of some material and ultimately recovered as a liquid containing nitrates in solution. Another way of accomplishing the same purpose would be to develop an intensive nitrifying capacity in some solid substratum which could be used as an absorbing material for urine. The principle involved in both cases is the same. It is the establishment of an intensive nitrifying bed.

In this paper it is proposed to give the results of laboratory studies undertaken with a view to find out whether it is possible to develop methods based on this principle.

In order to establish an intensive nitrifying bed the present writer started to get the cultures of nitrifying organisms by inoculating a small quantity of the local soil into 100 c.c. of Omelianski solution in a flask and containing 10 mg. of N as ammonium sulphate, and after the ammonium salt was nitrified (which takes place in nearly four to six weeks) a little of this solution was transferred to another flask containing the same solution. After a few transfers like this the organisms had become sufficiently active to serve as inoculating material for the nitrifying bed to be started. In the meanwhile study was made of the conditions for increasing the efficiency of the nitrifying organisms such as a suitable substratum, and the depth of the solution to be nitrified by carrying out some experiments under proper control. As a result of these, it was found that pumice or broken brick pieces serve as a good material for forming the bed (Table I) and that thin layers of nitrifying solutions

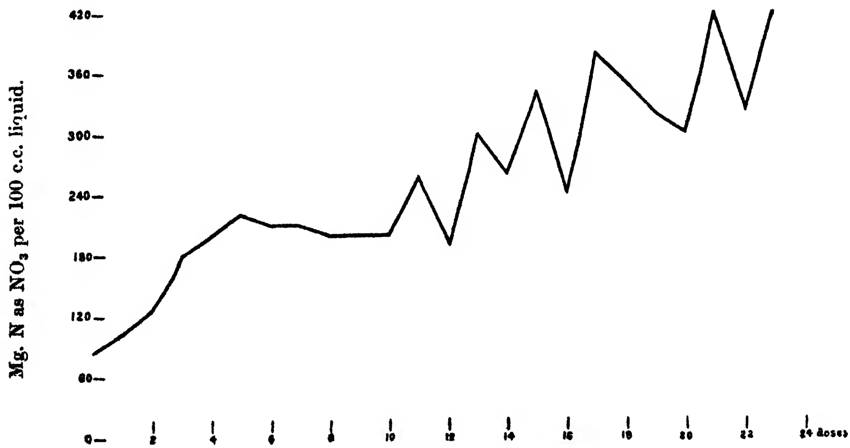

CHART 1.

are better than deeper ones (Table II). The nitrifying solutions were, therefore,

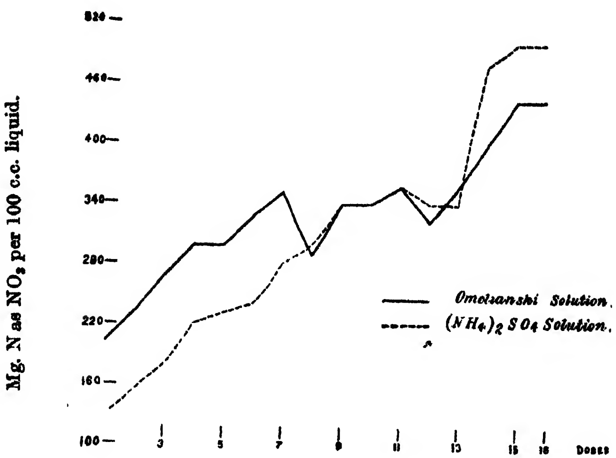

CHART II.

transferred to flasks containing these materials, the solution being kept in thin layers. After the nitrifying process was complete the solution was thrown out and a fresh solution was put in the same flask, the pumice or brick substrata being left undisturbed. When after a few changes of solution the cultures became active enough to nitrify the added Omelianski solution in one or two days instead of the four to six weeks required in the beginning, the dose of ammonium sulphate was gradually increased with each fresh addition and when the nitrifying bed was well established in this way its power of tolerating the nitrates already formed was tested by fresh additions of ammonium sulphate without removing the previously nitrified solution. The results of these experiments are set out in the curves (I and II) appended which go to show that the nitrifying organisms can acquire the property of tolerating a high concentration of nitrate nitrogen.

In the course of this investigation it was found that at certain intervals there is a loss of nitrogen which at first could not be accounted for. Attempts to find out whether there are any losses of nitrogen at a high concentration of nitrates were, therefore, made by keeping an account of the nitrogen added as ammonium sulphate and nitrogen recovered as nitrates. The following typical curve (III) shows, however, that these losses are only temporary, since, ultimately, the deficiency is made good by the appearance of the nitrogen as nitrates later on. We are unable to explain why this should occur, but we are led to suppose that the nitrates and the ammonium sulphate are assimilated or acted upon by the organisms

(it is immaterial whether nitrifiers or non-nitrifiers) and a third substance is pro-

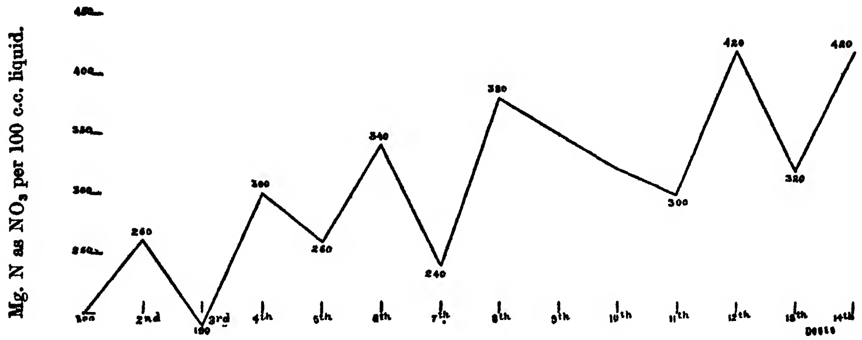

CHART III.

duced which does not give tests either of ammonia or nitrate.

TABLE I.

Nitrification experiments in Omelianski solution. 10 mg. nitrogen in 100 c. c.

Supporting materials in flasks	Nitrogen in mg. after days					
	3	6	10	14	16	34
Pumice . .	NO_2 0·3888	1·1016	2·754	2·4	4·860	..
	NO_3 1·0	1·25	1·25	1·375	1·375	6·5
Brick . .	NO_2 0·7775	2·43	4·212	nil	0·405	..
	NO 1·0	1·75	2·25	12·5	11·87	10·5

The same continued after adding 20 mg. nitrogen in the form of 100 c.c. Omelianski solution to both the bottles (after taking out the liquid already present therein).

Supporting materials in flasks	Nitrogen in mg. after days				
	3	6	10	14	18
Pumice . .	NO_2 0·2592	0·9072	0·0648	0·7128	nil
	NO_3 3·0	5·0	7·0	12·0	18·0
Brick . .	NO_2 0·486	3·24	0·729	0·648	nil
	NO 1·75	3·0	7·0	16·0	18·75

TABLE II.

Nitrification experiments in Omelianski solution. 10 mg. nitrogen in 100 c.c.

Treatment	MG. NITROGEN RECOVERED AS NITRATE AFTER DAYS			
	3	7	14	21
Depth of layer—				
2 inches . . .	0·750	1·37	7·8	11·70
4 inches . . .	0·750	0·86	3·25	11·70
6 inches . . .	0·624	0·625	2·6	11·70

Restarted after further addition of 40 mg. nitrate as ammonium sulphate per 100 c.c.

Treatment	MG. NITROGEN RECOVERED AS NITRATE AFTER DAYS				
	3	7	10	14	29
Depth of layer—					
2 inches . .	NO_3 4·0	27·0	30·0	28·0	28·0
4 inches . .	NO_3 7·5	28·0	34·0	32·0	35·0
6 inches . .	NO_3 5·0	12·0	16·0	22·0	27·0

Restarted after further addition of 40 mg. nitrate as ammonium sulphate per 100 c.c.

Treatment	MG. NITROGEN RECOVERED AS NITRATE AFTER DAYS				
	3	7	10	14	16
Depth of layer—					
2 inches . .	10·0	40·0	40·0	40·0	44·0
4 inches . .	13·0	27·0	31·0	31·0	41·0
6 inches . .	9·0	22·0	30·0	30·0	39·0

In connection with this we may add that this phenomenon is well known to soil bacteriologists, because at certain intermediate stages, in the course of nitrification in soils or solutions, it is not possible to account for all the nitrogen that is intro-

duced for nitrification but which later on reappears as nitrate. This has often been observed in this laboratory. Beesley[1], working under Dr. Fowler's direction, observed the same in his experiments, and he explains it by assuming that even in the apparently simple oxidation of ammonia to nitrous acid there is an intermediate stage in which hydroxylamine is formed. Dr. Fowler[2] considers that nitrification is doubtless a process of progressive hydroxylation of ammonia.

Without attempting to discuss the subject at any length we venture to remark that although the results of the above experiments appear to lend support to Dr. Fowler's hypothesis, yet in view of the fact that no investigator has definitely proved that hydroxylamine is present in the nitrifying solutions, another way of explaining the phenomenon should not be overlooked. Thus it may be assumed, for instance, that the nitrifying organisms, in the first stage, assimilate nitrate or ammoniacal nitrogen for their own multiplication and growth, and convert it into proteid or amino nitrogen, and subsequently (*i.e.*, after their full growth) oxidize and excrete it in the form of nitrate. The alternative succession of these two stages would explain the temporary disappearance of the nitrogen and its subsequent reappearance as nitrate later on.

To turn to our experiments. Having succeeded with quick nitrification of ammonium sulphate, similar experiments were next repeated with other sources of nitrogen such as ammonium carbonate, urine and sodium nitrite. With ammonium carbonate there was no trouble, the nitrification proceeded in the same way as with ammonium sulphate.

In the case of urine (Tables III and IV) it may be pointed out that urine required

TABLE III.

Nitrification of urine replacing ammonium sulphate in Omelianski solution.

—	Initial nitrogen in mg.	Mg. nitrogen recovered as nitrates after 15 days
Dilution—		
1—200	4·7	2·0
1—100	9·41	1·0
1—50	18·82	nil
1—25	37·64	nil
1—12	72·28	nil

[1] *Jour. Chem. Soc. Trans.* 1914.
[2] Fowler, G. J. *Jour. Indian Inst. Science*, Vol. 3, Pt. VIII, 1920.

TABLE IV.

Nitrification of urine.

—	Mg. nitrogen added to 100 c.c. solution	Days taken to convert the same into nitrate
Dilution with water—		
1—10	104	19
	Further addition	
	104	16
	104	12

much dilution before it could be nitrified. At first it was difficult to get it nitrified in four weeks even when diluted to 50 times, and therefore it was necessary to dilute it to one and even two hundred times, but after the first addition of diluted urine and slowly increasing the concentration with each dose we have reached a stage when it requires to be diluted about ten times only. It is not possible to say whether the ultimate limit has been reached or whether the organisms could stand a still higher concentration.

Nitrites as a source of nitrogen were tried because, as already known, the process of nitrification of ammonium sulphate takes place in two stages, and ammoniacal nitrogen requires to be first converted into nitrite nitrogen before its final transformation into nitrate nitrogen; and hence if these two stages are allowed to be carried on independently in different beds it was considered that they would work more efficiently without interfering with each other, as the efficiency of the later stage would not have to depend on the efficiency of the earlier one, and in this way they could perhaps be completed also earlier than usual. For this purpose four flasks of equal nitrifying efficiency (*i.e.*, nitrifying an equal quantity of ammonium sulphate in the same period of time) were divided into two batches. One batch received the nitrogen in the form of ammonium sulphate and the other nitrogen in the form of sodium nitrite. These were then compared for their nitrifying power. It was soon found, however, that the nitrite flask always lagged behind. We continued this experiment for over six months with the same unvarying result (Table V), from which it is concluded that the nitrate formers are able to effect the

TABLE V.

Nitrification experiments.

Number of days taken for 40 mg. nitrogen to form 100 c.c. nitrate bed.

Nitrogen added as ammonium sulphate	Nitrogen added as sodium nitrite
Days	Days
8	7
6	6
5	14
3	12
2	16
2	18
2	21

Maximum efficiency of nitrification of ammonium sulphate and sodium nitrite (in presence of optimum concentration of nitrate of each).

Maximum amount of nitrogen as ammonium sulphate converted into nitrates	Maximum amount of nitrogen as sodium nitrite converted into nitrates
40 mg. per day per 100 c.c.	14 mg. per day per 100 c.c.

nitrification more quickly if the nitrites are supplied in dilute doses as is brought about when they are formed from ammonium sulphate than by the nitrite forming organisms. This happens probably because the higher concentration of nitrite nitrogen is inhibitory to the organisms forming nitrates from nitrites. That even low concentrations are harmful to plant life is well known. Thus it had been observed in some experiments made in our laboratory at Pusa in 1914 that a concentration of 50 mg. nitrogen as potassium or sodium nitrite per 100 c.c. of the culture solution killed the maize seedlings within 1 to 3 days. While with the same concentration of nigtrogen as ammonium sulphate or potassium nitrate, the plants made good growth, showing that physiological dryness due to higher concentration of the salt (sodium nitrite) was probably not the cause of the

death of plants. In soil or sand cultures a concentration of nitrite nitrogen of 12 to 13 mg. per 100 grm. of soil was sufficient to kill the plants, showing that it was not the proportion of nitrites to the weight of soil that was responsible for the result but the proportion of nitrites dissolved in water. In other words, it was the concentration of nitrites dissolved in soil water that brought about the death of the plants in soil and sand cultures. It is rather interesting to observe that the nitrifying organisms which have the capacity to oxidize nitrites and so to say feed upon them should, however, work better when the nitrogen is supplied to them in the form of ammonium sulphate, a substance the nitrogen of which has to be converted into the nitrite form before being nitrified. The only reason why it should be so appears to be that when ammonium sulphate is the source of nitrogen, although it is rapidly converted into nitrites, there can never occur a concentration of nitrite nitrogen in the solution equal to that when nitrites act as the source of nitrogen, and that this initial higher concentration of nitrite nitrogen is inhibitory to nitrate formers, and hence the nitrate formers work much more efficiently when the nitrites are supplied to them in dilute doses. This view was found to be confirmed by the results of some further experiments with nitrate forming organisms in solutions containing varying concentrations of nitrites in separate flasks (Table VI).

TABLE VI.

Number of days taken for complete oxidation of 2 mg. nitrogen as nitrite.

Organisms	Contained in solution			
	100 c.c.	50 c.c.	20 c.c.	10 c.c.
No. 2	7	7	12	12
No. 3	8	10	12	12

This observation proved useful in another way inasmuch as colonies of organisms from the nitrifying organisms could be distinguished from those of the non-nitrifying ones in dilute nitrite solutions more quickly than in the stronger solutions formerly used.

These investigations have by now lasted for nearly two years, and as was naturally to be expected, we found that the process of nitrification goes on at laboratory temperatures more slowly in the cold season than in the hot weather. We get an idea of the efficiency of the process by determining the amount of nitrogen con-

verted into nitrates per cubic unit of space per day, and we find that in the cold season the efficiency is reduced on an average to 75 per cent. (Table VII). At the lowest temperatures recorded in the laboratory the efficiency went down to 60 per cent. of that observed in the warm period. There is thus a distinct seasonal variation due to temperature.

TABLE VII.

Nitrification experiments.

Treatment	MG. NITROGEN CONVERTED PER 100 C. C. PER DAY—AVERAGE OF 30 DAYS		NUMBER OF HOURS TAKEN TO CONVERT THE WHOLE INTO NITRATE—AVERAGE OF 30 DAYS	
	Hot season (30°C.)	Cold season (20°-25°C.)	Hot season (30°C.)	Cold season (20°-25°C.)
Dose of 40 mg. nitrogen as ammonium sulphate added successively after complete oxidation.	20	15	48	64

In our experiments we started with 50 c. c. of liquid and successively increased the capacity of the nitrifying bed to 100 and 250 c.c. and ultimately to 1 litre. We have been able to reach the same efficiency in each case, *i.e.*, the amount of nitrogen converted into nitrate has been found to be the same per cubic unit of space per day. As regards the amount of nitrogen that can be nitrified in this way continuously, we find that a litre solution containing 2 grm. of ammoniacal nitrogen can be completely oxidized by a nitrifying bed of a litre capacity in ten days. We propose to increase the cubic contents of the space occupied by the nitrifying bed but there is no reason to anticipate a lowering of the efficiency if we do so.

By this method of converting the nitrogen of the urine into nitrates we are enabled to get a liquid product which has an advantage in that it could be easily applied to the fields near by, the cost of labour for transporting being negligible. In case it is considered advisable to get *shora* or potassium nitrate, the solution has simply to be evaporated, the trouble and expense connected with the extraction of the nitre soil, etc., being eliminated.

While this method would be ideal under certain conditions, the liquid product may prove rather inconvenient to handle if it has to be carried a long distance and it may have to be absorbed by some solid material. The question then arises

that if some material has to be employed for absorbing the liquid product formed from the urine, why not begin by using it for absorbing urine. In this connection it occurred to the writer to devise what may be called an enriched nitrifying bed in the form of prepared or activated soil. It may be recalled that soil and straw were tried in our previous experiments as absorbing material but they proved ineffective on account of the fact that great losses of nitrogen occurred. It may be pointed out that these losses are chiefly due to rapid formation of ammonia in large amounts which is not as quickly nitrified as it is formed and hence it soon goes out of reach of the nitrifying organisms, a phenomenon well known to soil bacteriologists. We had met with this state of things in many of our earlier experiments when trying to find out the maximum capacity of soils to nitrify organic materials added to it. Table VIII illustrating two typical experiments in this direction

TABLE VIII.

Nitrification experiments with sarson cake in soil.

		1st week	2nd week	3rd week	4th week
Soil—extracted sarson cake @ 30 mg. nitrogen per 100 grm. soil.	NH_3	16·8	7·98	8·4	6·72
	NO_2	1·0886	6·9984	0·5832	0·03888
	NO_3	1·2	4·8	18·0	18·0
Soil—extracted sarson cake @ 120 mg. nitrogen per 100 grm. soil.	NH_3	47·54	42·12	42·84	27·3
	NO_2	nil	0·03888	nil	27·3
	NO_3	1·2	nil	Trace	0·9

Nitrification experiments with ammonium sulphate in soil.

		1st week	2nd week	3rd week	4th week
Soil—Am_2SO_4 @ 30 mg. nitrogen per 100 grm. soil.	NH_3	25·2	7·56	5·46	3·74
	NO_2	2·916	5·832	2·916	0·01944
	NO_3	Trace	4·8	12·0	31·2
Soil—Am_2SO_4 @ 120 mg. nitrogen per 100 grm. soil.	NH_3	91·98	83·56	68·88	34·86
	NO_2	0·02916	0·0486	0·0777	0·0388
	NO_3	Trace	Trace	0·9	0·9

is reproduced to show the course of decomposition with different amounts of nitrogen added to the soil for nitrification. Now this capacity of a soil to nitrify organic nitrogenous materials depends on many factors, chief of which we need consider are the number and efficiency of nitrifying organisms present in the soil. Looking upon the soil as a biological machine to turn out a certain product (in this case nitrates), our object is to improve the efficiency of this machine, which can best be achieved by increasing the number and physiological activity of the nitrifiers in the soil. We therefore began, as in the case of the liquid nitrifying bed, by giving small doses of nitrogenous materials within the capacity of the organisms already present in our soil (we may add parenthetically that practically any cultivated soil in any locality will do just as well); and after the nitrates were formed the soil was washed out so as to remove the nitrates and then dried and again used as a medium for the growth of the nitrifying organisms. If now the soil is divided into separate lots and different amounts of nitrogenous materials are added to each, it will be found that the capacity of the soil to nitrify is very much increased. In our experiments we tried only four times the quantity of nitrogen previously supplied and it was nitrified much quicker (Table IX). It is easy to see that by repeating

TABLE IX.

Nitrification experiment with soil in which nitrification had previously gone on for 4 weeks.

Treatment		1st week	2nd week	4th week
Soil previously nitrified and containing 18 mg. nitrate nitrogen initially.	NH_3	73·36	Not estimated	10·92
	NO_2	2·3328	0·3888	0·0388
	NO_3	21·6	43·2	72·0
Soil previously nitrified and containing no nitrite nitrogen initially.	NH_3	73·92	Not estimated	9·24
	NO_2	2·916	0·3499	0·0582
	NO	6·0	62·4	78·0

this process we will ultimately get a medium which will be able to nitrify higher and higher quantities of nitrogen. We have not yet determined the maximum efficiency that the soil will attain to in this way, but we have reached a limit where the activated soil nitrifies nearly sixteen times the nitrogen that it used to do in the beginning.

It might be gathered from what is written above that there is a possibility of the establishment of intensive nitrifying beds for the rapid conversion of the cattle urine into nitrates and saving its nitrogen from loss by evaporation, and that suitable

methods could be developed to carry this out in practice by using different materials as carriers of nitrifying bacteria. It is not possible, however, to give exact details of the methods, as the question is rather of wide interest and the needs of cultivators in different places are not alike, and hence those desirous of preventing the loss of nitrogen from the cattle urine by this process will have to make some preliminary trials to determine the size of their nitrifying bed according to the quantity of cattle urine at their disposal. It is presumed, however, that those wishing to undertake such trials, without previous experience, would find it useful to have a description of the practical methods depending on the principle of intensive nitrification in practice. A brief sketch of working the processes is, therefore, given here so as to enable each individual to make his trials, with such modification as may be necessary according to local requirements.

The Liquid Nitrifying Bed Method.

Taking the first method in which the final product is a liquid containing nitrates in solution, it may be pointed out that the chief thing necessary is to develop intensive beds for nitrifying the urine. The beds may be formed in some pits, preferably near the cattle shed so that the urine could be directly led into them. The pits are filled with some material like broken brick pieces or *kanker* which act as carriers of the nitrifying organisms and are useful in providing the aeration necessary for the rapid nitrification.

The next thing that is necessary is the introduction of the useful nitrifying bacteria into these beds before they can be used as nitrifying beds. There is no necessity to get special cultures of these. The purpose will be served by leading some urine diluted with water and adding some fertile soil into the pits. The urine will get slowly nitrified and this can be ascertained by the absence of the peculiar urine smell and the disappearance of ammonia in the liquid. The liquid can now be taken out of the pit and fresh urine, more concentrated than before, put in. This process will have to be repeated for some time, when the dilution of urine need only be about fifteen times or less. Now the bed may be taken to have established itself. The number and size of such pits to be used as nitrifying beds will no doubt depend on the quantity of urine available. The pits will have to be made impervious by cementing or by placing tiles at the bottom, but the walls need not be cemented because any urine that will seep through into the soil will be nitrified there and the soil could be extracted of its nitrate or used as manure. Instead of pits the process can be carried on in *ghailas* or earthenware jars also, thereby showing that the method is workable within very wide limits. The pits should receive the urine in rotation so that by the time the last is full the first should have completed the nitrification and be ready to receive another lot.

With nitrification proceeding at the average rate it will take 8 or 10 days to completely nitrify one gallon of urine (containing 1 per cent. nitrogen) in a nitri-

fying bed of $\frac{1}{7}$ cubic foot. Taking this as a basis, the number and size of pits may be determined according to the quantity of urine available. It has to be borne in mind, however, that sometimes the process lags behind, and the provision of extra space is necessary in order to meet any such untoward contingency. Making allowance for this, we may say that a rectangular pit of two cubic feet dimensions divided into 14 compartments will be able to deal with one gallon of urine per day. In this process the resulting product will be liquid and the contents of the pit will be nitrified within a short time. The pits will therefore require to be emptied every ten days or a fortnight.

The Activated Soil Method.

Many will for this reason prefer the second method of using the activated soil for the purpose of nitrifying the urine. To them we would recommend the following method which is capable of adaptations as may be necessitated by the quantity of urine to be absorbed and the space available for absorbing it. In this method the enrichment of the soil with nitrifying organisms should be done by adding to it some urine diluted with water in the beginning. In case of the Pusa soil the following proportions were found to be suitable to make the soil moist and yet friable: 3 parts of urine, 100 parts of soil and 12 parts of water. After four weeks, the nitrified soil should be washed out of its nitrate and the washed soil dried under shade and again used. This may now be treated with 12 parts of urine to 100 parts of soil with the necessary quantity of water to make it sufficiently moist and again allowed to nitrify. The process may be repeated if necessary by increasing the quantity of urine. After two or three such repetitions, the soil will generally be in a fit condition for directly absorbing urine with a high nitrogen content. When the soil is thus ready it may be filled in pits. The pits shall be so situated that urine from the cattle shed can be conducted into them by a channel. If the pit is of sufficiently large dimensions, the process of activating the soil may be carried on in the pit itself by adding urine and water to the soil in the pit in the proportions stated above. In this case although it may take a little longer time to activate the soil, the process of washing out the nitrates can be done away with and repeated additions of urine directly made as a measure of economy. When the pits are full of activated soil they should be marked out into 28 compartments by ridges of the soil, and urine should be added daily to each of these compartments by turns. By the time the last compartment is filled with urine, the first compartment will have completed its nitrification and will be ready to receive a second dose of urine. Similarly the other compartments will also be ready in succession. After six or eight such doses of urine, which will take 24 to 32 weeks, the soil in the pits will be ready for manuring, and can be taken out and the pit refilled with fresh soil. The activated soil contained in a pit of the dimensions of 6 feet long × 2 feet wide × 6 inches deep divided into 28 compartments will conveniently deal with a

daily output of one gallon of urine containing 1 per cent. nitrogen. The dimensions of the pit may be altered to suit one's convenience so long as the right proportions of cubic space and the nitrogen to be nitrified are observed. Thus the same cubic space may be divided into two or three pits of smaller size to enable one to conveniently handle the soil of each pit separately.

In presenting the above outline of the two methods the writer would like to take the opportunity to observe that the data on which the outlines of working the processes is based were obtained from a large number of experiments continuously carried out for over two years in the bacteriological laboratory at Pusa and may be taken as absolutely reliable so far as the experiments go ; yet the drawbacks which generally attend any application of the results of laboratory experiments to large scale trials will naturally present themselves in this case also, and the writer, although confident of the results obtained in the laboratory, cannot but expect that difficulties will arise in translating the results of his experiments into actual practice. The outline of the processes given above should not, therefore, be treated as an authoritative account of a well established practice but rather as a guide to critically examine a promising but as yet only a newly recommended process.

Before finishing we could just call attention to one other consideration. It is in fact an answer to the question as to what gain will accrue from spending so much labour on saving urine. If we consider for one moment the amount of nitrogen contained in cattle urine almost all of which is wasted at present we will get some idea as to the saving likely to be effected. The urine excreted by cattle is put down in text books from 10 to 40 pints per head per day, the quantity varying according to the age and size of the animals as well as the season and the diet given. Let us suppose that on an average 2 gallons of urine is excreted by one animal in 24 hours. The amount likely to be saved is therefore 1 gallon or 10 lb. during the time that the animals are kept in the cattle sheds. Urine of cows that we experimented with contained on an average 1 per cent. nitrogen. The nitrogen in the urine saved from one cow is therefore about 0·1 lb. per day, which means in one year 36·5 lb. of nitrogen per head of cattle. If all this nitrogen were converted into say potassium nitrate, we get 2·5 mds. of potassium nitrate by extracting it from the nitrified soil. Even if we are able to recover only 40 to 50 per cent. of this quantity because of the crudest method employed, it will mean 1 to 1¼ mds. of potassium nitrate or *shora* or an equivalent amount of nitrogen recovered from the urine. The cultivator is at present allowing this to go to waste. Is it not then worth his while to turn his attention to this problem and convert the cattle urine into some material which will prove useful to his crops or bring money into his pocket ?

It will thus be seen that the methods advocated here are not merely of academic interest ; though they may look tedious at first, they are none the less quite practicable. In this connection we may refer to two papers by Boullanger in *Annales*

de L'Institut Pasteur, Vols. 35 and 36. This author has used an elaborate apparatus, including iron tanks and pumps, for filtering and raising the liquid to be nitrified from tank to tank, and used ammoniacal salt solutions in his work. Working on a semi-industrial scale the author has shown that it pays to produce nitrates from the solution obtained after nitrification of ammoniacal salts in this biochemical process if the nitrification proceeds rapidly enough, *i.e.*, if the rate of nitrification is such that 75 litres of a solution containing 1·5 grm. ammoniacal nitrogen per litre are converted into nitrates by passing through a bed of peat 1 cubic metre in space in a day. This means that 0·75 litres of a solution containing 1·5 grm. of ammoniacal nitrogen per litre should be nitrified in a bed of peat of 1 litre capacity in 10 days for economically working it.

In our experiments we get in the cold season 1 litre of a solution containing 1·5 grm. of ammoniacal nitrogen per litre completely nitrified in 10 days in a bed of one litre capacity, which is 33 per cent. higher than that required for economically working the method according to Boullanger's figures. The amount of nitrogen converted into nitrates in the hot season is again 33 per cent. higher than that of the cold season. From this it will be easily seen that in our method for nitrification of urine the rate of nitrification considered as economic from an industrial point of view will be maintained without much difficulty. Further it may be pointed out that in our experiments we waited for the complete disappearance of ammonia before adding a fresh dose of ammonium salt. It is not, however, necessary in practice to wait for the disappearance of the final traces of ammoniacal nitrogen, and consequently in practical working of the process we may expect to realize a higher rate of nitrification than what we have given above.

We think, therefore, that the principle of the intensive nitrifying bed is very likely to succeed in practice if trials are made on a scale larger than what is practicable in the laboratory.

Summary.

Large losses of nitrogen occur when cattle urine is preserved under aerobic conditions. It was considered that it would be possible to prevent such losses if the urine could be passed over intensive nitrifying beds where it could be subjected to the rapid action of nitrifying bacteria which would convert it into nitrates before any loss takes place. Experiments were therefore undertaken to find out whether such intensive nitrifying beds could be established and whether urine would be nitrified without loss of nitrogen, and it has been found that there are two ways of accomplishing this in practice. In one the urine is passed over a nitrifying bed and ultimately recovered as a solution of nitrates. In the other method the urine is absorbed by means of a specially prepared or activated soil.

A general outline of working these processes is included in the paper to enable those interested in the subject to make their own trials.

In the first method, pumice or broken bricks serve as suitable substrata for the organisms in the nitrifying bed. The depth of layer of liquid to be nitrified possesses great influence over the nitrification process. Urine could not be nitrified directly without dilution in the nitrifying beds up till now. With the most active bed prepared so far urine requires to be diluted with ten times the quantity of water.

In the second method soil prepared by previously nitrifying some nitrogenous material in smaller quantities and washing out the nitrates is used for absorption of urine. If ordinary local soil is used for absorbing the urine directly without any such preparation large losses of nitrogen (approximately 70-80 per cent. of the original amount) occur. The object of preparing the soil is to activate the nitrifying organisms and thus make the soil capable of nitrifying the high quantities of nitrogen in the urine rapidly and thus prevent losses of nitrogen which would otherwise occur.

It is estimated that about 2·5 mds. of potassium nitrates, *i.e.*, pure *shora*, may be obtained from a single animal's urine (containing about 1 per cent. of nitrogen) if it were converted into potassium nitrate by this process of intensive nitrification, provided no loss of nitrogen took place during handling.

Even if the crudest method of handling alone is possible for any individual resulting only in 50 per cent. recovery of the nitrogen in urine as nitrate, and the nitrogen content of the urine of animals be half of what was found in the case of the dairy herd at Pusa, it is estimated that 1-1¼ mds. of potassium nitrate or a manure containing an equivalent amount of nitrogen therein will be easily obtained per year if the urine of a pair of animals is regularly subjected to this process. It will be seen therefore that the urine of animals conserved in this way will go a long way to meet the manurial requirements of the cultivators.

INHERITANCE OF CERTAIN CHARACTERS IN *GOSSYPIUM*.*

BY

K. I. THADANI, M.Sc., B.Ag., F.L.S., F.R.H.S.,

Cotton Breeder in Sind.

The genus *Gossypium* furnishes an unusual wealth of materials in the way of distinct varietal and specific types. Probably no other genus of crop plants contains so many domesticated species, to say nothing of endless varietal forms to be found in all cotton-growing countries.

The cotton plant has numerous specialized characters some of which are very important from the plant breeder's point of view. The breeder differentiates these important characters into two main groups, firstly those which tend to increase the intrinsic value of the crop, secondly those which help in keeping his strains or varieties pure. In order to breed suitable types with desirable characters the plant breeder must have an intimate knowledge of these characters, their mode of inheritance, and how they react to environment. In this paper we propose to describe the mode of inheritance of certain characters of practical significance to plant breeders and the cotton farmers at large.

1. Inheritance of seed fuzziness in cotton.

The mode of inheritance of the distribution of fuzz on the seed has been investigated in the past by Balls[1] in Egypt and McLendon[2] in the United States. The results obtained in the experiments about to be described do not seem to coincide with those of the earlier experiments and throw a new light on the subject.

Before describing our results it may be appropriate to make clear the vague use of the terms expressing the distribution of the fuzz on the seed. For convenience sake cotton seeds may be grouped according to the distribution of the fuzz on the seed-coat as follows :—

Group 1. Naked seeds. Seeds having absolutely smooth seed-coat as possessed by some American Uplands and a strain of Sea Island cotton.

Group 2. Partially fuzzy seeds. These are characteristic of all Egyptians and also some strains of Sea Island. In these seeds a portion of the seed-coat to a greater

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* Paper read at the Agricultural Section of the Indian Science Congress, Bangalore, 1924. The experiments described in this paper were carried out at the Agricultural and Mechanical College, Texas, U. S. A.

[1] Balls, W. L. Some cytological aspects of cotton breeding. *A. B. A. An. Rep.* 1909.

[2] McLendon, C A. Mendelian inheritance in cotton hybrids. *Ga. Exp. Stn. Bull.* 99.

or less extent is uncovered and the rest is more or less fuzzy. Thus the Sea Island strains have almost smooth seeds which have small tufts of fuzz at both ends. The Mit-afifi variety of Egyptian cotton has a naked patch on the back of the seed and the remaining portion is very fuzzy. The Yuma variety of Arizona Egyptian cottons has most of the seed-coat smooth with little tufts of fuzz at two ends extending along the raphe. The Pima variety of American Egyptian cottons again has much more fuzz than the Yuma.

Group 3. Entirely fuzzy seed-coat. The American Upland cottons have mostly, with few exceptions, seeds which have fuzz distributed all over the seed-coat. The same is the case with Indian cottons. This group may for convenience be sub-divided into (*a*) woolly, (*b*) felted, (*c*) scanty fuzz, such that the dark coat of the seed can be seen through.

Behaviour of various kinds of seeds.

Naked seeds. Entirely naked seed as present in the Upland cotton variety called No Lint is completely dominant in the F_1 generation over fuzzy seed (all the three sub-divisions) of some of the American Upland cottons (Plate I, fig. 1).

In the F_2 generation the segregation is in accordance with the simple Mendelian inheritance as may be seen from the following table :—

Table I.

F_2 segregation of naked versus entirely fuzzy seed in cotton.

Serial No.	Cross	No. of individuals			Remarks
		Naked	Entirely fuzzy	Total	
1	Durango × No Lint .	30	7	37	Durango parent has a woolly seed.
2	No Lint × Lonestar .	14	5	19	Lonestar parent has a woolly seed.
3	No Lint × Texas Rust .	41	14	55	Texas Rust parent has a woolly seed.
4	Black Seed × No Lint .	16	6	22	Black Seed parent has a scanty fuzz.
5	Acala × No Lint . .	53	18	71	Acala parent has a woolly seed.
6	Acala × No Lint . .	49	16	65	Acala parent has woolly seed.
	Observed totals . .	203	66	269	
	Calculated on simple Mendelian inheritance.	201·75	67·25	269	

The ratios obtained clearly show that this pair of characters is determined by a single pair of factors and expectations were fulfilled in the F_3 generation.

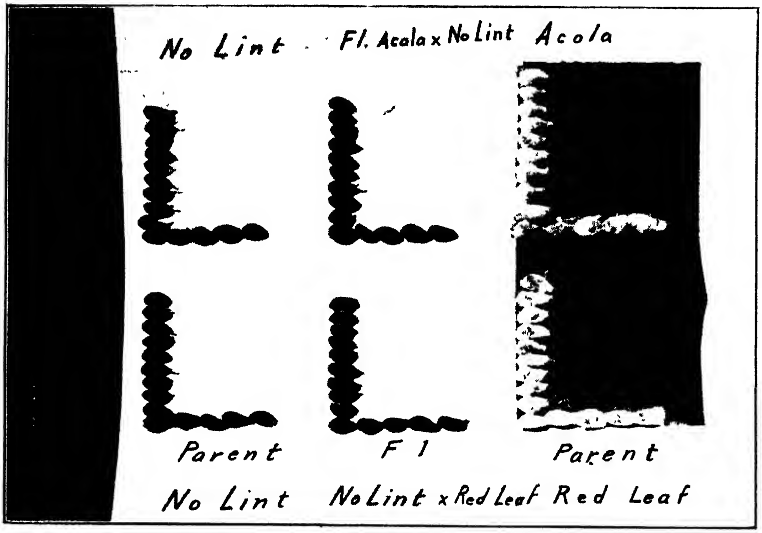

FIG. 1. *Top* (*from left*) Naked parent, F_1 hybrid, Fuzzy (woolly) parent
Bottom (*from left*) Naked parent, F_1 hybrid, Fuzzy (felted) parent

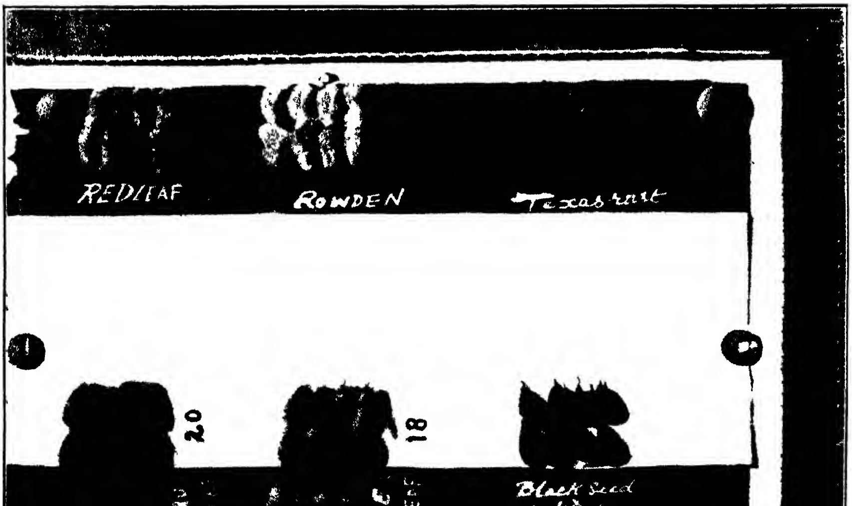

FIG. 2. *Top* (*from left*). Felted, woolly and woolly parents.
Bottom (*from left*). F_1 Woolly × felted, Woolly × felted, Naked × scanty fuzz.

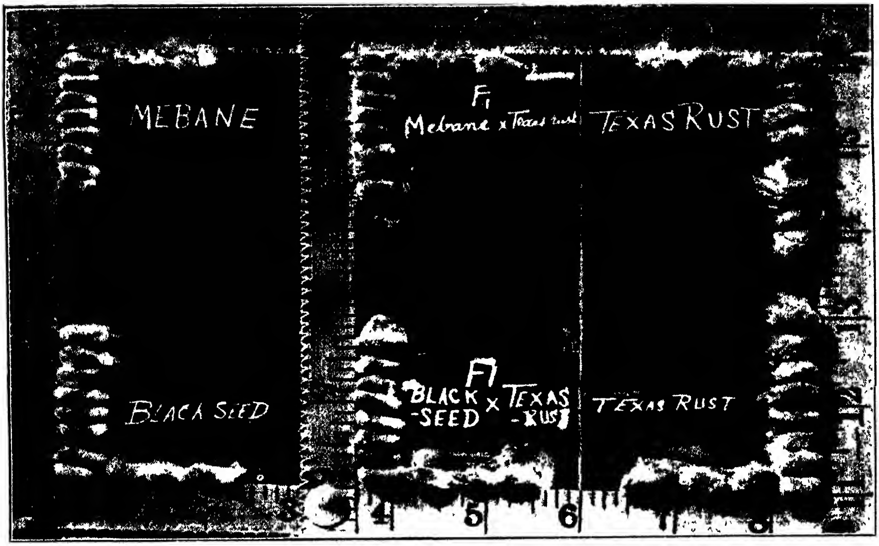

FIG. 1. *Top (from left).* Felted parent, F_1 hybrid, woolly parent.
Bottom (from left). Scanty fuzz parent, F_1 hybrid, woolly parent.

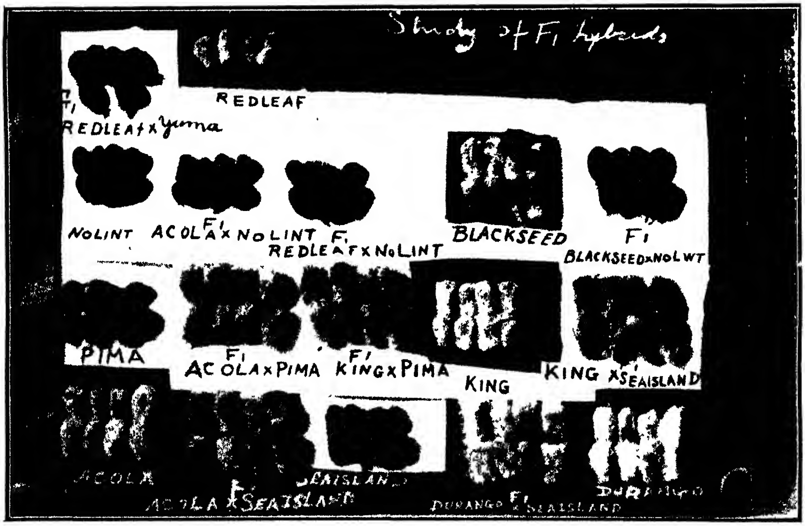

FIG. 2. *Top (from left).* 1, Entirely fuzzy × partially fuzzy; 2, Entirely fuzzy parent.
Second row. 1, Naked seed parent ; 2 & 3, Wholly fuzzy × naked ; 4, Scanty fuzzy parent ; 5, Scanty fuzz × naked.
Third row. 1, Partially fuzzy parent ; 2 & 3, Wholly fuzzy × partially fuzzy ; 4, Wholly fuzzy parent ; 5, F_1 Upland × Sea Island.
Bottom. 1, Wholly fuzzy parent ; 2, King Upland × Sea Island ; 3, Sea Island parents ; 4, Durango × Sea Island ; 5, Durango.

Entirely fuzzy seeds. As already mentioned, there are three sub-divisions of entirely fuzzy seeds, *viz.*, woolly, felted, scanty fuzz. In the cross Felted × Woolly, felted seed was dominant (Plate I, fig 2 ; Plate II, fig. 1), and the F_2 generation was too small to compute a ratio. In the cross Scanty Fuzz × Woolly, scanty fuzz was dominant (Plate I, fig. 2) and the F_2 generation in this case also was too small.

It may be interesting to observe that Balls in his early investigations came to the conclusion that 'little fuzz' is dominant over 'no fuzz' and 'entire fuzz' dominant over 'little or no Fuzz.' Similar results are reported by McLendon. These results are often cited by cotton investigators as generally true but our experiments show that the reverse is the case. Thus the forms which are indistinguishable phenotypically may not necessarily have the same genetic constitution. Balls was dealing with Egyptian crosses while the experiments here described refer to American Upland crosses. Cases of factor interaction are also widely known. The plant breeder must, therefore, take caution in accepting the results of certain crosses as being generally applicable to all cottons.

Partially fuzzy seeds. All Egyptian cottons and some strains of Sea Island cotton come under this class. These when crossed with entirely fuzzy seed of American Upland cottons show that the latter are dominant in the F_1 generation except in one case, which will be treated separately. In the F_2 generation the ratios obtained varied in the several crosses, in one case 19 individuals of entirely fuzzy type and 1 of partially fuzzy type were found ; many plants were infertile. F_2 population presented such a mass of heterogeneous individuals as would permit of no grouping. Apparently several factors are involved in these crosses. These results are in agreement with those obtained by Balls and McLendon since the crosses were identically the same.

The Yuma variety of Egyptian cotton has a seed-coat which is mostly naked except small tufts of fuzz at the ends extending along the raphe. This seed when crossed with entirely fuzzy seed of American Upland cottons behaves differently from other Egyptian and Sea Island cottons grouped under "partially fuzzy seeds" in being dominant over the Upland type (Plate II, fig 2). In the F_2-generation five kinds of seeds were obtained ranging in seed fuzziness from absolutely naked seeds to entirely fuzzy seeds. The ratios obtained were as follows :—

TABLE II.

F_2 segregation, Egyptian-Upland cross, Yuma × Red Leaf.

Phenotype	No. of individuals
1. Entirely naked seed	3
2. Seed almost naked with little fuzz at one end	5
3. Yuma type of seed with very little fuzz at two ends and along raphe .	10
4. Entirely fuzzy (felted green)	10
5. Entirely fuzzy (woolly)	10

The behaviour of this cross in the F_2 generation shows that many factors are involved. F_3 generation has not been grown. Kearney[1] has also observed a similar behaviour of the Yuma variety. He states "the apparent dominance of a less fuzzy over a more fuzzy condition of the seed-coat in this presumably first generation hybrid is exceptional, since according to Balls 'little fuzz' is dominant over 'no fuzz' and 'entire fuzz' is dominant over 'little or no fuzz.'"

2. Inheritance of amount of Lint on the Seed.

This character has been investigated by McLendon.[2] In a cross of Sea Island with Cook's Big Boll (an Upland variety), McLendon states, 'low percentage' is dominant to 'high percentage' and in the F_2 generation the original percentages reappear, with variations extending even beyond the extremes of the parental percentages. This pair of characters behaves differently in the varietal crosses of American Upland cottons as compared to the behaviour of the interspecific crosses quoted above. In these experiments it is found that 'high percentage' is dominant over 'low percentage' in the varietal crosses of American Upland cotton as noticed in the following crosses :—

(1) No Lint × Lonestar.
(2) No Lint × Texas Rust.
(3) No Lint × Acala.
(4) No Lint × Red Leaf.

The amount of lint is measured by lint percentage and also by lint index. The latter gives the weight of lint on 100 seeds and is not much affected by the size of the seed as would be the case in calculating the lint percentage ; and hence it is more accurate an expression of the amount of lint. In these crosses the No Lint parent has a lint index of 0–1 (grm. of lint per 100 seeds) as compared to the lint index of the other American Upland varieties ranging from 3–5·5 (grm. of lint per 100 seeds). The percentage of No Lint variety ranges from 0–10 and that of the other American Uplands from 26–36. The parents are easily distinguishable by the naked eye, although in some crosses actual weights have been taken as a check measure.

The following ratios have been obtained in the F_2 generation :—

Table III.

Segregation of high amount of lint versus low amount of lint in cotton.

Serial No.	Cross	No. of individuals in F_2			Remarks
		High	Low	Total	
1	No Lint × Lonester . . .	14	5	19	
2	No Lint × Texas Rust . .	41	14	55	
3	No Lint × Red Leaf . . .	58	19	77	
4	No Lint × Acala . . .	101	35	136	
	Observed Totals	214	73	287	
	Calculated	215·25	71·75	387	

[1] Kearney, T. H. *Jour. Agri. Res.*, May 16, 1921, p. 229.
[2] McLendon. *Ibid.*

FIG. 1. Lint length of parents.

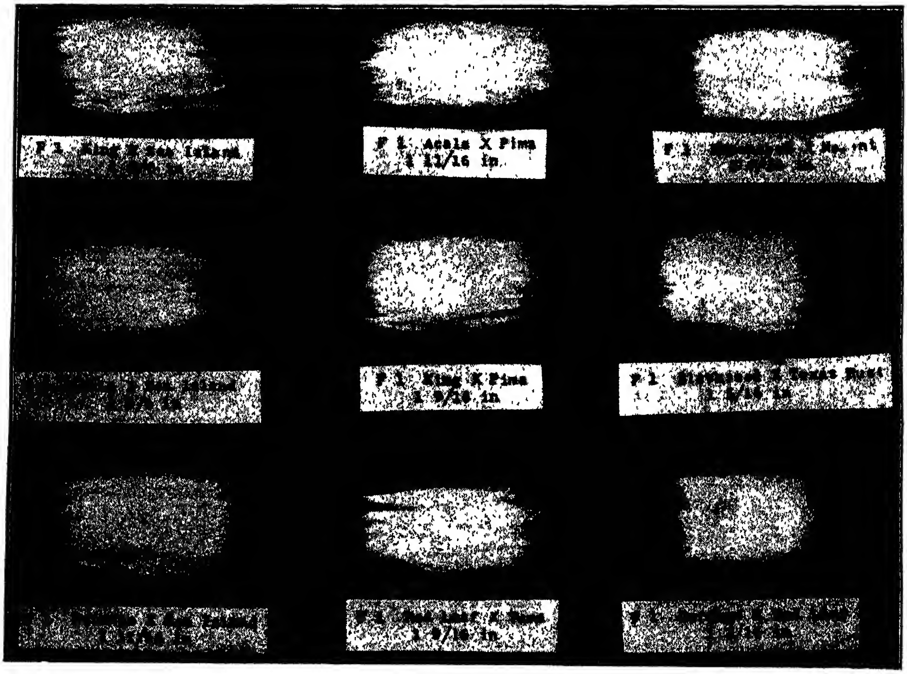

FIG. 2. Lint length of F_1 hybrids.

The ratios obtained indicate that a single factor is involved in this pair of characters, and expectations were fulfilled in the F_3 generation.

3. Inheritance of Length of Lint.

It is a matter of common knowledge that some cottons are long-stapled and others short-stapled. Long staple seems to be dominant over short in the F_1 generation as found in the following crosses (Plate III).

Table IV.

Staple length of parents and F_1 hybrids.

One Parent		Other Parent		F_1 Hybrid
Variety	Length in inches	Variety	Length in inches	Length in inches
I. Interspecific cross.				
Sea Island	$1\frac{11}{16}$	Acala (Upland)	1	$1\frac{3}{4}$
Sea Island	$1\frac{11}{16}$	Durango (Upland)	$1\frac{1}{8}$	$1\frac{11}{16}$
Sea Island	$1\frac{11}{16}$	King (Upland)	$\frac{7}{8}$	$1\frac{5}{8}$
Pima (Ariz. Egyptian)	$1\frac{3}{8}$ to $1\frac{3}{4}$*	Acala (Upland)	1	$1\frac{11}{16}$
Pima (Ariz. Egyptian)	$1\frac{5}{8}$ to $1\frac{3}{4}$	King (Upland)	$\frac{7}{8}$	$1\frac{9}{16}$
Yuma (Ariz. Egyptian)	$1\frac{9}{16}$	Red Leaf (Upland)	$1\frac{7}{16}$	$1\frac{9}{16}$
II. Varietal cross.				
Black Seed (Upland)	$1\frac{7}{16}$	Texas Rust (Upland)	$\frac{7}{8}$	$1\frac{3}{16}$
Black Seed (Upland)	$1\frac{7}{16}$	No Lint (Upland)	$\frac{7}{8}$	$1\frac{1}{4}$
Red Leaf (Upland)	$1\frac{7}{16}$	Texas Rust (Upland)	$\frac{7}{8}$	$1\frac{1}{8}$

The F_2 generation in some crosses could not be investigated for reasons beyond control; in others the ratios obtained varied in the several crosses so that no theoretical ratios seem to be suggested in the counts. In the F_2 population of the interspecific crosses there was a great tendency towards sterility.

Conclusions.

1. Forms which are indistinguishable phenotypically may not have the same genetic constitution and hence the mode of inheritance in certain crosses may vary

for the visibly similar characters in other crosses. Hence the plant breeders are cautioned to accept the results of crossing experiments as being generally applicable without reference to the types involved in the cross.

2. Most of the characters of economic significance show dominance in the F_1 generation and hence the desirable combinations are not so easy to segregate as would be the case if the desirable characters were recessive. In the case of seed fuzziness it is however found that the fuzzy seed is recessive to naked seed. Since many of the American Upland cottons often contain a few naked seeds, advantage of recessive nature of the fuzzy seed may be taken in purifying the crop by mechanically removing the naked seeds.

3. The significance of the study of the mode of inheritance in staple crops is of vital interest in agriculture, since improvement of crops is one of the most fundamental lines of progress.

SELECTED ARTICLES

PRESENT-DAY PROBLEMS IN CROP PRODUCTION.*

BY

SIR E. JOHN RUSSELL, F.R.S.

COMPLEXITY OF THE PROBLEM.

THE agricultural investigator is confronted with three closely interlocking agencies—the plant, the climate and the soil—each of which is variable within certain limits, and each playing a large part in the crop production which it is his business to study.

Confronted with a problem of this degree of complexity there are two methods of procedure: the empirical method of field observations and experiments in which there is no pretence of great refinement and no expectation that the same result will ever be obtained twice, it being sufficient if over an average of numerous trials a result is obtained more often than would be expected from the laws of chance; and the scientific method, in which the factors are carefully analysed and their effects studied quantitatively; a synthesis is then attempted, and efforts are made to reconstruct the whole chain of processes and results. The scientific method is of course, the one to which we are naturally attracted. But common truthfulness compels one to admit that up to the present the greatest advances in the actual production of crops have been effected by the empirical method, and not infrequently by men who are really artists rather than men of science, in that they are guided by some intuitive process which they cannot explain, and that they have the vision of the result before they obtain it, which the scientific man commonly has not.

The best hope for the future lies in the combination of the empirical and the scientific methods. This is steadily being accomplished by the recent strong infusion of science into the art of field experimentation, which has much enhanced the value of the field work and the trustworthiness of its results. Modern methods of replication, such as have been worked out at Rothamsted and in the United States by Harris of the Carnegie Trust (Cold Spring Harbour), Kiesselbach in Nebraska, Myers and Love of Cornell, and others, constitute a marked improvement in plot technique. The figures themselves, besides being more accurate, can be made to yield more information than was formerly the case.

* From the presidential address delivered to Section M (Agriculture) of the British Association, Toronto, 1924. Reprinted from *Nature*, No. 2864.

Great advances have been made in the methods of analysing the results. The figures are never the same in any two seasons, since the climatic conditions profoundly affect the yields. A few men, like J. H. Gilbert, have the faculty of extracting a great deal of information from a vast table of figures, but in the main even the trained scientific worker can make very little of them. The reason is that he has been brought up to deal with cases where only one factor is varying, while the growth of plants involves the interaction of three variable factors : the plant, the soil, and the climate. It is impossible to apply in the field the ordinary methods of the scientific investigator where single factors alone are studied ; very different methods are needed, adapted to the case, where several factors vary simultaneously.

Fortunately for agricultural science, statisticians have in recent years worked out methods of this kind, and these are being modified and developed by R. A. Fisher and Miss Mackenzie for application to the Rothamsted field data. It so happens that this material is very suitable for the purpose, since a large number of the field experiments have been repeated every year for seventy or eighty years on the same crop and on the same piece of land, using the same methods ; the field workers also remain the same for many years, the changes being rare and without break in continuity . Although the statistical investigation is only recently begun, mathematical expression has already been given to the relationship between rainfall and yield of wheat and barley under different fertilizer treatments, and precision has been given to some of the ideas that have hitherto been only general impressions. If on an average of years a farmer is liable to a certain distribution of rainfall, it is becoming possible to advise as to fertilizer treatment which enables the plant to make the best of this rainfall.

Alterations in the Plant.

It is a commmonplace among farmers that certain soil conditions influence not only the yield but also the quality of crops. The leaf and root are more easily affected than the seed. The case of mangolds has been investigated at Rothamsted ; the sugar content of the root, an important factor in determining feeding value, was increased by increasing the supply of potassium to the crop. Middleton at Cockle Park showed that grass increased in feeding value—quite apart from any increase in quantity—when treated with phosphates. Potatoes are considerably influenced by manuring ; increasing the supply of potassium influences the composition of the tubers and also that much more impalpable quality—the cook's estimate of the value of the potato ; while we have found at Rothamsted that a high class cook discriminated between potatoes fertilized with sulphate of potash and those fertilized with muriate of potash, giving preference to the former.

Grain is more difficult to alter by changes in environmental conditions ; indeed, it appears that the plant tends to produce seed of substantially the same composition whatever its treatment—with the important exception of variation in moisture

supply. Mr. Shutt has explored the possibilities of altering the character of the wheat grain by varying the soil conditions, and finds that increases in soil moisture decrease the nitrogen in the grain. Similar results have been obtained in the United States.

On the other hand, in England the reverse seems to hold, at any rate for barley. This crop is being fully investigated at the present time under the research scheme of the Institute of Brewing, because of its importance in the preparation of what is still Britain's national beverage. Increased moisture supply increases the percentage of nitrogen in the grain, and so also does increased nitrogen supply, though to a much less extent; on the other hand, both potassic and phosphatic fertilizers may decrease the percentage of nitrogen, though they do not always do so; the laws regulating their action are unknown to us.

The practical importance of these problems of regulating the composition of the plant lies in the fact that the farmer can control his fertilizer supply, and also to some extent his moisture supply, so that it lies within his power to effect some change should he wish to do so.

In agricultural science one sometimes thinks only of the crop and the factors that affect its growth. But in agricultural practice there is often another partner in the concern: a pest or parasite causing disease. The amount of damage done by pests and diseases to agricultural crops is astounding; in Britain it is probably at least 10 per cent. of the total value of the crops and the loss is probably some £12,000,000 sterling per annum; in some countries it is considerably more. Indeed, the number of insect pests and of harmful fungi and bacteria that skilled entomologists and mycologists have found in our fields might almost lead us to despair of ever raising a single crop, but fortunately the young plant, like the human child, grows up in spite of the vast number of possible deaths. The saving fact seems to be that the pest does harm only when three sets of conditions happen to occur together: the pest must be present in the attacking state; the plant must be in a sufficiently receptive state; and the conditions must be favourable to the development of the pest. It is because this favourable conjunction of conditions comes but rarely that crops manage to survive; and this gives us the key to control if only we knew how to use it. Complete control of any of these three conditions would end all plant diseases. Unfortunately, control is never complete even in glasshouse culture, still less out of doors. But even partial control would be very helpful. All these pests go through life-cycles, which are being studied in great detail all over the world, and especially in the United States. Somewhere there occurs a stage which is weaker or more easily controlled than others, and the pest would become harmless if the chain could be broken here or if the cycle could be sufficiently retarded to give the plant a chance of passing the susceptible stage before it is attacked.

The plants themselves, as we have just seen, are in some degree under control and if they could be pushed through the susceptible stages before the pest was ready,

they would escape attack. Barley in England is sometimes considerably injured by the gout fly (*Chlorops tæniopus*). The larvæ emerge in spring from the eggs laid on the leaves and invariably crawl downwards, entering the young ear if, as usually happens, it still remains ensheathed in leaves. J. G. H. Frew, at Rothamsted, has shown that early sowing and suitable manuring cause the ear to grow quickly above the track of the larvæ, and thus to escape injury. E. A. Andrews, in India, has found that tea bushes well supplied with potassic fertilizer escape attack from the mosquito bug (*Helopeltis*) for the rest of the season, apparently because bushes so treated become unsuitable as food to the pest. Further, the conditions are alterable. H. H. King, in the Sudan, has effected some degree of control of the cotton thrips (*Heliothrips indicus*) by giving the plant protection against the drying north wind and so maintaining a rather more humid atmosphere—a condition in which the plant flourishes more than the pest. Tomatoes in England suffered greatly from *Verticillium* wilt until it was found that a small alteration of temperature threw the attack out of joint. They are also much affected by stripe disease (*B. lathyri*), but they become more resistant when the supply of potash is increased relative to the nitrogen. It has recently been maintained, though the proof is not yet sufficient, that an altered method of cultivating wheat in England will afford a good protection against bunt. These cultural methods of dealing with plant diseases and pests offer great possibilities, and a close study jointly by plant physiologists and pathologists of the responses of the plant to its surroundings, and the relationships between the physiological conditions of the plants and the attacks of its various parasites, would undoubtedly yield results of great value for the control of plant diseases. Again, however, the plant breeder can save a world of trouble by producing a variety resistant to the disease ; or there may fortunately be found an immune plant from which stocks can be had, as in the case of the potatoes found by Mr. Gough to be immune to the terrible wart disease.

Control of Environmental Factors.

It thus appears that, if only plant breeders and plant physiologists could learn to alter existing plants or to build up new plants in such a way that they should be well adapted to existing soil and climate conditions, and not adapted to receive disease organisms at the time the organisms are ready to come – if only they could do this, all agricultural land would become fertile and plant diseases and pests would become ineffective : at any rate until the pests adapted themselves to the new plants. Although no one can set limits to the possibilities of plant breeding and plant physiology, we cannot assume that we are anywhere near this desirable achievement or that we are likely to be in our time.

There will always remain the necessity for altering the environmental conditions to bring them closer to the optimum conditions for the growth of the plant. No attempt is yet made in the field to control two of the most important of the factors :

the light and the temperature, though it is being tried experimentally. There is a great field for future workers here; at present plants utilize only a fraction of the radiant energy they receive. At Rothamsted attempts have been made by F. G. Gregory to measure this fraction; the difficulties are considerable, but the evidence shows that our most efficient plants lag far behind our worst motor-cars when regarded as energy transformers for human purposes. One hundred years ago the efficiency of an engine as a transformer of energy was about 2 per cent.; now, as a result of scientific developments, it is more than 30 per cent. To-day the efficiency of the best field crops in England as transformers of the sun's energy is about 1 per cent.*: can we hope for a similar development in the next hundred years? If such an increase could be obtained an ordinary crop of wheat would be about 400 bushels per acre, the farmers would feel sorry for themselves if they obtained only 200 bushels. But we are only at the beginning of the subject. Increases in plant growth amounting to some 20 or 25 per cent. have been obtained by V. H. Blackman in England under the influence of the high-tension electric discharge, which presumably acts by increasing in some way the efficiency of the plant as an energy transformer. Possibly other ways could be found. It needs only a small change in efficiency to produce a large increase in yield. Much could be learned from a study of the mass of data which could be accumulated if agricultural investigators would express their results in energy units as well as in crop yields as at present.

Interesting results may be expected from the attempts now being made in glass-house culture both in Germany and at Cheshunt to increase the rate of plant growth by increasing the concentration of the carbon dioxide in the atmosphere.

Control of the Soil Factors.

The soil factors lend themselves more readily to control and much has already been achieved. Water supply was one of the first to be dealt with. Civilization arose in the dry regions of the earth, and so far back as 5,000 years ago, irrigation was so advanced as a practical method that it came into the ordinances drawn up by the great Babylonian king Hammurabi. The chief problems at the present time are to discover effective means of economizing water and to ascertain, and if possible to control, the relationships between the soil, the water, and the dissolved substances in the water.

Inseparably bound up with water supply are the questions of cultivation and of drainage, which affect not only the water but the air supply to the roots. The former subject is now attracting considerable attention; the great need is to discover means for expressing cultivation in exact physical and engineering units. The measurements of Keen and Haines at Rothamsted, and the chemical work of A. F. Joseph,

* The remaining energy being largely used up in transpiration. This figure refers to the total radiation received by the leaf, and not to the fraction received by the chloroplast surface. For this latter the value is much higher.

N. Comber, and others on clay, and of Oden Page and of others on humus, indicate the possibility of finding exact expressions and of effecting co-operation with the workers in the new fields of agricultural engineering.

Another soil factor which readily lends itself to some degree of control is the amount of plant nutrients present. The possibility of increasing this by means of manure has been so frequently explored in field trials that it has sometimes been regarded as almost a completed story; indeed, Rothamsted tradition affirms that Lawes himself once gave orders to have the Broadbalk field experiments discontinued because they had nothing further to tell; it was only the earnest persuasion of Gilbert that caused him to countermand the order. So far from the subject being exhausted, it still bristles with problems. The new nitrogenous fertilizers, resulting from war-time activities in nitrogen fixation; the need for reducing the cost of superphosphate; the change in character in basic slag; and the Alsatian development in potash production, are producing changes in the fertilizer industry the full effects of which are not easy to foresee. Economic pressure is driving the farmer to derive the maximum benefit from his expenditure on fertilizers, lime, farmyard manure, and other ameliorating agents, and is compelling a more careful study of possibilities hitherto disregarded, such as the use of magnesium salts, silicates, and sulphur as fertilizers, and above all, a much more precise diagnosis of soil deficiencies than was thought necessary in pre-war days.

There are, however, more fundamental problems awaiting solution. It is by no means certain that we know even yet all the plant nutrients. The list compiled by Sachs many years ago includes all needed in relatively large amounts, but Gabriel Bertrand has shown that it is not complete and that certain substances—he studied especially manganese—are essential although only in very small amounts. Miss Katherine Warington, working with Dr. Brenchley at Rothamsted, has shown that leguminous plants fail to develop in the so-called complete culture solution unless a trace of boric acid is added. Maze has indicated other elements needed in small amounts.

Another problem needing elucidation is the relationship between the quantity of nutrients supplied and the amount of dry matter produced. Is dry matter production simply proportional to nutrient supply, as Liebig argued, with the tailing off beyond a certain point, as demonstrated by Lawes and Gilbert, or is it always less than this, as indicated by Mitscherlich's logarithmic curve; or is the relationship expressed by one of the more complex sigmoid curves as there is some reason to suppose? We do not know; and the problem is by no means simple, yet it governs the "diminishing returns" about which farmers hear so much.

Again, very little is known of the relationship between nutrition and the period of growth of a plant. One and the same quantity of a nitrogenous fertilizer, for example, may have very different effects on the plant according as it is given early or late in life; not only is there a difference in quantity of growth but also in the

character of growth. Late dressings cause the characteristic dark-green colour to appear late in the season, and thus affect the liability to fungoid diseases; they increase the percentage of nitrogen in the grain and they may give larger increases of crop than early dressings.

Investigations are needed to find the best methods of increasing the supply of organic matter in the soil and its value for the different crops in the rotation.

All these problems will sooner or later find some solution. But there remains a greater problem of more importance than any of them: the linking-up of plant nutrition studies with those of the soil solution. As our cousins in the United States were the first to emphasize, the fundamental agent in the nutrition of the plant is the soil solution, and they made a remarkable series of investigations into what appeared at one time a hopeless proposition—the physico-chemical interactions between the soil and the soil water. A great advance in crop production may be expected when the soil chemists have discovered the laws governing the soil solution, when the plant physiologists can give definite expression to the plant's response to nutrients, and when some one is able to put these results together and show how to alter the soil solution so that it may produce the maximum effect on the plant at the particular time. The new soil chemistry will yet have its triumphs.

The Soil Micro-organisms.

It is now more than forty years since the discovery of the great importance of micro-organisms in determining soil fertility. Practical applications necessarily lag far behind; but already three have been made each of which opens out great possibilities for the future. The long-standing problem of inoculation of leguminous crops with their appropriate organisms has already been solved in one or two of its simple cases, chiefly lucerne on new land, and the new process has helped in the remarkable extension of the lucerne crop in the United States and in Denmark. We believe at Rothamsted that the more difficult English problem is now solved also. Interesting possibilities are opened up by the observation that a preliminary crop of Bokhara clover seems to facilitate the growth of the lucerne.

The organisms effecting decomposition are now coming under control, and are being made to convert straw into farmyard manure (or a material very much like it) without the use of a single farm animal. The process was worked out at Rothamsted, and is being developed by the Adco Syndicate, which is now operating it on a large scale and is already converting some thousands of tons of straw annually into good manure.

The third direction in which control of the soil organisms is being attempted is by partial sterilization. This process is much used in the glasshouse industry in England, and it has led to considerable increases in crop yields. The older method was to use heat as the partial sterilizing agent, and this still remains the most effective,

but owing to its costliness, efforts have been made to replace it by chemicals. Considerable success has been attained ; we have now found a number of substances which seem promising. Some of these are by-products of coal industries ; others, such as chlor and nitro-derivatives of benzene or cresol, are producible as crude intermediates in the dye industry.

The Need for fuller Co-operation.

Looking back over the list of problems it will be seen that they are all too complex to be completely solved by any single worker. Problems of crop production need the co-operation of agriculturists, plant physiologists, soil investigators, and statisticians. Even plant breeding necessitates the help of a physiologist who can specify just what the breeder should aim at producing. This gives the key-note to the period of agricultural science on which we have now entered—it is becoming more and more a period of co-operation between men viewing the problem from different points of view. Good individual work will of course always continue to be done, but the future will undoubtedly see a great expansion of team work such as we know from our experience at Rothamsted is capable of giving admirable results in agricultural science.

With fuller co-operation both of men and of institutions we could do much to overcome the present difficulty in regard to utilizing the information we already possess. In the last thirty years an immense stock of knowledge has been obtained as to soils and crops. It is stored in great numbers of volumes which line the shelves of our libraries, and there much of it rests undisturbed in dignified oblivion. In the main it consists of single threads followed out more or less carefully ; only rarely does some more gifted worker show something of the great pattern which the threads compose. But even the most gifted can see but little of the design ; the best hope of seeing more is to induce people to work in groups of two or three, each trained in a different school and therefore looking at the problem from a different point ; each seeing something hidden from the rest. Unlike art science lends itself to this kind of team work ; art is purely an individual interpretation of Nature while science aims at a faithful description of Nature, all humanistic interpretation being eliminated. There is certainly sufficient good will among the leaders of agricultural science to justify the hope of co-operation ; there are probably in existence foundations which would furnish the financial aid.

This leads to my last point. What is the purpose of it all ? Team work, co-operation, the great expenditure of time and money now being incurred in agricultural science and experiment—these are justified only if the end is worthy of the effort.

The nineteenth century took the view that agricultural science was justified only in so far as it was useful. That view we now believe to be too narrow. The practical purpose is of course essential ; the station must help the farmer in his

daily difficulties—which again necessitates co-operation, this time between the practical grower and the scientific worker. But history has shown that institutions and investigators that tie themselves down to purely practical problems do not get very far; all experience proves that the safest way of making advances, even for purely practical purposes, is to leave the investigator unfettered. Our declared aim at Rothamsted is "to discover the principles underlying the great facts of agriculture and to put the knowledge thus gained into a form in which it can be used by teachers, experts, and farmers for the upraising of country life and the improvement of the standard of farming."

This wider purpose gives the investigator full latitude, and it justifies an investigation whether the results will be immediately useful or not—so long as they are trustworthy. For the upraising of country life necessitates a higher standard of education for the countryman; and education based on the wonderful book of Nature which lies open for all to read if they but could. How many farmers know anything about the remarkable structure of the soil they till, of its fascinating history, of the teeming population of living organisms that dwell in its dark recesses; of the wonderful wheel of life in which the plant takes up simple substances and in some mysterious ways fashions them into foods for men and animals and packs them with energy drawn out of the sunlight— energy which enables us to move and work, to drive engines, motor-cars and all the other complex agencies of modern civilization? No one knows much of these things; but if we knew more and could tell it as it deserves to be told, we should have a story that would make the wildest romance of human imagination seem dull by comparison and would dispel for ever the illusion that the country is a dull place to live in. Agricultural science must be judged not only by its material achievements, but also by its success in revealing to the countryman something of the wonder and the mystery of the great open spaces in which he dwells.

Sir John Russell writes in "Nature," dated 1st November, 1924:—

On returning from a lecturing tour in Canada and the United States, I find among the files of *Nature* "Cantab's" interesting letter in the issue of 27th September.

I had no intention of being despondent in my address to Section "M" (Agriculture) of the British Association, nor is there occasion for despondency. It is true that science has given only few aids to agriculture of the order of 100 per cent. increase in yield, but much has been done of a less spectacular nature, and agricultural experts are now able to advise farmers with considerably more certainty than was the case even thirty years ago. There have been great changes in practice, and science has helped considerably. The history of agriculture shows that advances have come in three ways: from purely empirical methods tried by farmers with no definite scientific plan; from experiments on empirical lines made by trained workers;

and from advances in pure science, whether initiated in a purely scientific, or, as has often happened, in a technical laboratory. It is a fact that in the past some of the biggest advances have been made by empirical methods, but one cannot infer that scientific methods are therefore inferior ; only in recent years have they been adequately tried. Our knowledge of the biochemical changes in the soil, of the soil micro-organisms, the soil solution, and the soil colloids, quite apart from the genetical work to which " Cantab " referred, has all come as the result of the purely scientific work, done solely with the view of gaining information, and with no idea of practical applications. Little of this knowledge is yet used in practice, for the simple reason that no one has found a way of using it, but all history shows that the application comes sooner or later once the scientific discovery is definitely established. There is every reason to hope that agricultural science has fresh triumphs in store.

In recent years it has been easier to apply scientific methods in agricultural investigations because many of those responsible for the management of agricultural institutions, and especially the younger men, appreciate their value and realize the necessity for the so-called " academic work." No honest person working on scientific lines would ever commit himself to a definite promise that a particular investigation would have practical results ; he can, however, so conduct it that it will yield sound knowledge. It is of course true, as " Cantab " points out, that epoch-making discoveries have not yet come direct from team work or directed research. But it must also be recognized that advances of this order are in any case very rare, and when they come it is largely as the result of the less spectacular, but none the less real, advances in knowledge which can be made in the well-equipped organized institution. No research institution can do more than hope for first order discoveries, but the staff can, at any rate, ensure good development work, and secure advances which in the aggregate count for much.

Like all other forms of research, agricultural research is finally limited by the state of knowledge of other branches of science ; and a logical scheme of assistance would recognize the claims of all pure science. The present schemes may not be very logical, but knowing something of the methods by which a research institute has to be sustained, I am not sure that the departments of pure science have always adopted the best methods for obtaining assistance. A great difficulty of research institutions—and it must be far greater to the layman—is to know just what are the methods and the results of science, in other words, whether the limitation imposed by lack of knowledge in pure science lies in the man or the science. The agricultural investigator received his training in pure science it may be ten or twenty years ago ; he tries to keep up, but is overwhelmed by the enormous and ever-increasing volume of papers of very varying merit and lucidity. The Chemical Society facilitates his task by issuing annual reports on the different branches of chemistry, and many other scientific societies have not followed this good example. There must be many papers in pure science buried in the libraries which would prove of great value to agriculture if they were known, but they are not. At Rothamsted we have

adopted various devices for keeping in touch with pure science, one of the best of these being to bring young men and women from the purely scientific laboratories from time to time to take part in our work. This is one example of the "team work" to which I referred in my address as being among the hopeful ways of securing advances in agricultural science, another being co-operation between institutions engaged on different aspects of what may be fundamentally one and the same problem.

Team work makes it possible for the different workers to keep in touch, and to utilize advances made in other subjects. It has other advantages too, for even the wisest of mortals will never see a scientific problem as a whole, but only in part.

THE PRACTICAL AIMS OF THE DAIRY FARMER.*

BY

JAMES MACKINTOSH, O.B.E., N.D.A.,

National Institute for Research in Dairying, University College, Reading.

The chief practical aim of the dairy farmer must of necessity be the same as that of any other business man who invests his capital in some form of industry, namely, the obtaining of the largest average net profit over a period of years.

This aim can only be realized by good all-round management, and farm management includes many operations of very diverse character, such as purchase of live stock, feeding stuffs, manures, etc., of the kinds most suitable for the farm in the most economical manner; efficient organization of labour; selection of the most suitable crops, followed by adequate cultivation and good judgment at harvesting; wise use of home-grown and purchased foods; careful treatment of all kinds of live-stock, and the sale of milk, dairy produce, surplus stock and crops in the most advantageous manner.

The second practical aim of the dairy farmer must, therefore, be successful management of those branches of the farm organization which contribute most largely to the annual expenditure and the annual receipts. It is difficult to arrange these branches in a generally accepted order of importance, and fortunately this is not essential; some stand out clearly as absorbing major portions of the annual payments, *e.g.*, purchase of feeding stuffs, manures and seeds, occasional purchase of in-calf heifers and cows, and expenditure on labour; others are equally definite as the chief contributions to the annual income, *e.g.*, sale of milk and dairy produce, surplus live-stock and surplus crops. In addition to the actual buying and selling, there is the important work of using the commodities purchased in the most advantageous manner for the production of the goods to be sold. This article will, therefore, be devoted to a brief consideration of the aims of the dairy farmer in each of the above-mentioned branches of the farm management.

PURCHASE AND USE OF FEEDING STUFFS.

Numerous investigations have shown that the cost of purchased feeding stuffs is one of the largest items in the cost of milk production, hence the need for careful

* Reprinted from *Jour. Min. Agri.*, XXXI, p. 516,

study of the composition and nutritive value of available cake and meals in relation to price and suitability for use along with home-grown foods. The aim of the farmer should be to provide a balanced ration of suitable foods at the minimum cost. The home-grown foods—hay, straw, roots, silage, cereal grains, beans, etc.,—usually constitute the bulk of the ration, and purchase of other foods must be made in accordance with the supplies already on the farm. Space does not permit of a detailed discussion here of the principles and practice of feeding, but every dairy farmer ought to have, for easy reference,[1] information on (*a*) the composition of feeding stuffs; (*b*) the work done in the animal body by the different constituents—albuminoids, oil, etc.; (*c*) at least one method of valuing feeding stuffs according to their analysis, and he should also be familiar with the so-called feeding standards for milk production which specify the quantities of food needed to maintain the dairy cow in ordinary condition and to produce a given quantity of milk. The use of these feeding standards, combined with a knowledge of the composition of feeding stuffs, has given excellent results in the compounding of rations and in lessening the cost of milk production in many countries.

One instance of the value of such knowledge may be given. In the early winter of 1923 two of the cheapest feeding stuffs on the market were rice meal (£7 per ton), and extracted undecorticated groundnut meal (£6 15*s.* per ton). Reference to the analysis of these foods showed that the former contained: albuminoids 13 per cent., oil 13 per cent., and cabohydrates 50 per cent.; starch equivalent, 72. The latter contained: albuminoids 32 per cent., oil 2 per cent., and carbohydrates 22 per cent.; starch equivalent, 45.

When mixed in equal proportion in weight, the mixture contained 22½ per cent. albuminoids, 7 per cent. oil, 36 per cent. carbohydrates, with a starch equivalent of 58·5, and cost £6 17*s.* 6*d.* per ton. A further study of tables of food compositions showed that the percentage of digestible albuminoids would be about 17, and this percentage, with a starch equivalent of 58·5, would give a fairly well balanced mixture for milk production; one in fact, which would fit in very well with an average maintenance ration of home-grown roots and hay. With regard to price, comparison with other feeding stuffs showed that, with two exceptions, the above-mentioned mixture was obtainable at a price per ton appreciably lower than any other single food or mixture of foods of similar composition on the market; in fact, numerous other foods with similar percentages of albuminoids and oil were quoted at £9 or thereabouts per ton. The exceptions just referred to were palm kernel (extracted) meal and palm kernel cake. A glance at the composition of these foods, however, showed that either of them could be used in equal proportions, along with the rice

[1] *Min Agri., London, Miscellaneous Publication* No. 32 (Rations for live-stock).

meal and groundnut meal, and the resulting mixture would still be well balanced for cows in milk; for example :—

	Albuminoids		Oil Total	Carbo-hydrates Total	Fibre Total	Starch equiva-lent Total
	Total	Digest.				
Rice meal	13	7	13	50	7	72
Undec. extr. groundnut meal	32	27	2	22	24	45
Extr. palm kernel meal .	19	16	2	49	16	71
Mixture	21·3	16·6	5·6	40·3	15·6	62·6

The percentage of indigestible fibre in the above mixture is higher than is desirable for heavy milking cows, but for average herds a mixture of the above composition has been proved quite satisfactory. Other mixtures containing less indigestible fibre and consisting of more appetising ingredients could easily have been made up, but when the relative costs per ton were compared, the advantage on the side of the cheaper mixture was a strong argument in favour of its use, at least for the first three gallons produced per cow. Cows giving higher daily yields could be given a more appetising mixture for the gallons yielded over three per day.

The fact that in one season market prices of feeding stuffs should vary so much that one or two properly balanced mixtures can be obtained for fully £2 per ton less than other foods of similar analysis constitutes a very practical reason why dairy farmers should have a knowledge of the principles and practice of rationing for milk production. Consideration should also be given to the probability that feeding stuffs can be purchased more cheaply during the summer than during the winter, and it is certain that the price per ton can be cut somewhat when an order is given for a large quantity of one kind of food. There is a certain amount of risk in buying forward, but on the average the purchaser gains; it is usually possible to get sufficient information during the summer as to the trend of prices, and it is preferable to consider groups of alternative foods rather than individual varieties.

There is a wealth of evidence that the important point in a ration is a correct balancing of the albuminoids, carbohydrates, etc., rather than the inclusion of any one or two particular foods, and the object of the farmer should be to purchase such foods as will give a properly balanced ration in conjunction with those grown on the farm.

The benefit obtainable by purchasing a large quantity of any food is fully appreciated by the large farmer, but this advantage can also be obtained by those farming on a smaller scale if they will agree to use the same foods and pool their orders. This

can be done privately, but a large development of this principle should lead to the formation of a co-operative society to organize purchases on a still larger scale.

Purchase and use of Manures and Seeds.

The amount spent annually by the dairy farmer on manures and seeds is as a rule materially less than the expenditure on purchased foods, and the importance of these items in the annual expenditure will naturally vary according to the proportion of arable and grass on the farm.

The principles governing the selection of manures for different soils and crops are now generally understood, and information on the current prices per unit is easily available as a guide to the farmer in the purchase of his requirements. It is nevertheless desirable to emphasize two points; firstly, the importance of obtaining manures of high grade and reliable quality, and, secondly, the comparison of the cost per unit when the railway carriage, cartage and cost of application is taken into account in addition to the first cost of manure. For example, a grade of basic slag with 20 per cent. total phosphate may be quoted at 41*s*. per ton, equal to 2·05*s*. per unit, and a grade with 34 per cent. total phosphate at 63*s*. per ton, equal to 1·86*s*. per unit. These figures show only a slight difference in favour of the higher grade, but further consideration shows that 6 tons of the latter will supply as much phosphate as 10 tons of the former. The purchase of the higher grade, therefore, means a distinct saving in railway carriage and cartage, and in the cost of application per acre.

With regard to the purchase of seeds all that need be said here is to urge the importance of buying always clean seed of excellent quality.

Purchase of Heifers, Cows and Bulls.

From the point of view of the prospective dairy farmer the purchase of heifers and cows to constitute the foundation of a herd is of the greatest importance, and were this article written primarily for beginners, this subject would have received first consideration. On the other hand, a very large number of dairy farmers are able to maintain their herds by the introduction of home-bred stock and rarely purchase heifers or cows. Where such a course is possible it is in the writer's opinion the best method of maintaining a herd because of the possibility of improvement in milk yield and breed type from year to year, but this improvement will only be gained if great care is given to the choice of a stock bull. In breeding herds, therefore, one of the chief practical aims is the selection and purchase of a bull with a view to the breeding of heifers of greater milking capacity and of better type than their dams.

In the selection of heifers and cows for the commencement or maintenance of a herd, attention should be directed chiefly to the age, type, breeding (including if possible the milk records of the parents), and place of origin. Many dairy farmers

prefer always to purchase first-calf heifers and this course has much to recommend it, because heifers purchased at or soon after calving give an immediate return for their keep, are usually healthier than older cows, and, should they prove unsatisfactory as milkers, they can be disposed of at a price which shows little or no depreciation on their original cost. The quantity of milk produced by a herd of first-calf heifers is not equal to that produced by a herd of mature cows, but the greater risk of a considerable depreciation in the value of the latter usually turns the scale in favour of the younger animals. Where second-calf cows can be purchased from a healthy herd, they may be preferred to first-calf heifers because they will give larger yields, and the shape and size of the udder and position of the teats can be seen better.

Milk recording has made great progress in recent years, but as yet records are not available in respect of dams and grand dams of the great majority of the heifers available for purchase, hence, purchasers must depend on selection by external characteristics—conformity to breed type, size, constitution and healthiness and potential milking capacity as denoted by udder and milk vein development. In this connection it is interesting to note that one of the American Agricultural Experiment Stations has recently published the results of a comprehensive study of the relative importance of the different milk yield "indicators" in the Jersey breed. The degree of correlation between the actual yield, as shown by lactation records, and conformation of different parts of the body as measured by the marks awarded on a score card basis, was found to be surprisingly wide ; the most reliable indicators were found to be : (1) the milk veins, which should be large, tortuous, and elastic ; (2) the hindquarters of the udder, which should be well rounded and well out and up behind ; (3) the udder, which should be of large size and not fleshy ; and (4) the body, which should be wedge-shaped with deep large paunch, legs proportionate to size and of fine quality. The same investigators, however, point out that the actual yield of milk as found in a seven-day period a few weeks after calving is twice as accurate an indication of the cow's ability to produce milk as any external features or "points" of the animal.

It is highly probable that these conclusions are also largely applicable to other breeds, and the value of milk records in the sale and purchase of dairy cattle is thus confirmed from another point of view. The purchaser of dairy stock is therefore less likely to be disappointed in his purchases if he selects stock privately from milk-recorded herds or from complete dispersal sales of such herds. He must, however, study the published records closely, remembering that information as to the milk yields, number of days in milk, and dates of calving for two or three successive years are much more reliable basis for judgment than the yield for one year or lactation period only.

To the owner of an established dairy herd, the selection of a young bull is one of the most important practical points. The only true means of improvement of a herd is by breeding, and the test of improvement is that the home-bred heifers should

be better animals and better milkers than their dams; the chief agent in this improvement must therefore be the bull. If we assume that the dairy farmer on the look out for a young bull can be relied on to make a good selection on the basis of external appearance according to the points of the favoured breed, there are at least two other points which should be studied. The first is the dairy characteristics of the bull's dam and, if possible, his grand dams: these cows should be of good breed type, healthy and with well-developed shapely udders and teats. The second point is the milk records of the dam and grand dams; these should be studied in detail as specified above in regard to the records of cows, remembering that an average of, say, 9,000 lb. over three successive years is a more valuable indication of constitution and milking properties than a one year's yield of 11,000 lb. to 12,000 lb. A third point which should be studied in some instances is the percentage of fat in the milk of the dam and grand dams. On this point there will most probably be little or no information obtainable, but nevertheless there are good reasons why intending purchasers should persist in asking questions on this point. It is well known that as a rule (though fortunately there are occasional exceptions) heavy milking cows yield milk of less than average quality, hence the continued selection of bulls on the basis of milk yield only will tend to lower the average quality of the milk produced by the herd and increase the risk of trouble with the local authorities responsible for the administration of the Food and Drugs Acts. To many dairy farmers the main object is to get an increased yield from their herd, and if the use of a bull, the son of a heavy-yielding dam whose milk averaged only 3 per cent. of fat, would ensure an increase of 100 to 200 gallons per cow, they would take the bull and risk any trouble in respect of quality. There are, however, many others who have already high herd averages, and in such cases the quality of the milk should receive attention; buyers of milk are likely to have an increasingly wide field of producers to select from, and discrimination may be exercised to the disadvantage of those whose milk is troublesome in respect of quality.

Management of the Dairy Herd.

A dairy herd is kept for the purpose of producing milk, hence the management should include all those details which experience and research have shown to be advantageous and economical. Milk recording has proved its value in hundreds of cases as a means of improving the average yield and thus giving a larger sale of milk from the same number of cows with the same expenditure on labour and other overhead charges. Butter-fat testing in herds where the milk is made into butter or cheese has also shown how the output from the herd can be increased; where young bulls are sold for stock purposes, information as to the fat percentage in the milk of the dam may enable a higher price to be obtained. Service and calving records should be carefully kept to enable cows to be dried off in preparation for the following actation period, and times of service should be regulated so that cows will calve at

the time when the maximum production of milk is most desirable or when it is most profitable.

All cows should be marked by tattooing or some other method so that they can be identified, and all calves reared for stock purposes should be similarly marked and a record kept of the tattoo number or markings so that they may be identified and their ancestry traced when necessary. Failure to mark calves so that they can be identified later has caused numerous herd owners to lose many years in the grading-up of stock for registration in the Breed Herd Book. Milk Recording Societies, operating under the regulations of the Ministry of Agriculture, now undertake the tattooing of calves and keep the necessary records, and membership of one of these societies affords the easiest and most reliable means whereby records of milk yields, butter-fat percentages, calving and service dates and the tattoo numbers of cows and young stock can be obtained. The cost of membership is not great and, though the farmer must at present consider carefully every item of expenditure, the money spent on milk recording and calf marking should be looked on as a good investment, for there is no doubt that in the course of time it will return a highly satisfactory rate of interest.

Another important aspect of herd management is the maintenance of a thoroughly healthy dairy herd free from contagious abortion and tuberculosis, and with the minimum of udder troubles. Probably the most effective precaution which can be taken to prevent outbreaks of contagious abortion is to rear sufficient young stock to maintain the herd, thus making purchase of female stock unnecessary, and to keep a bull for the herd. The same procedure is also very desirable when a tubercle-free herd has been obtained through the application of the tuberculin tests and elimination of reacting animals. In spite of the criticism still occasionally directed against the tuberculin tests there is a steady increase in the number of practical dairy farmers who are convinced that the application of the tests and action according to the results obtained is well worth while, because in addition to freedom from tuberculosis, herds of non-reacting animals are healthier in every other respect. With regard to udder troubles the chief precautions are close observation, immediate treatment of every affected quarter according to the nature of the trouble, isolation of the cow when necessary and particular attention to cleanliness in housing and milking.

In all matters affecting the health of a herd the advice and assistance of a veterinary surgeon should be sought without hesitation, and there can be no doubt that the circumstances are most favourable to successful treatment in herds of home-bred stock (where the life-history of each animal is known), housed, fed, watered, and milked under cleanly conditions.

Organization of Labour.

On many farms the wages bill is the largest single item in the annual expenditure. The first essential is to get one or more good men who understand the work

of herd management and of land cultivation, and who are not afraid of responsibility. A good herdsman or head cowman is well worth good wages; if his duties and responsibilities be considered in detail it is at once realized that no expenditure by the owner of time and money in the selection and breeding or purchase of valuable dairy stock, or in the provision of model equipment can ensure success without the whole-hearted co-operation of the men who feed, milk and attend to cows at calving time, deal with cases of udder trouble and the numerous other small but nevertheless important items in the management of a dairy herd.

The only school from which such men can be obtained is that of experience, and although occasionally it may be imperative to make a change in order to get a more reliable staff, as a rule the problem before each farmer is to consider what steps he can take to arouse a greater and more intelligent interest in their work on the part of the men he already employs.

Assuming that the farmer himself is keenly interested in the welfare of his herd and in all details of herd management, there are a variety of ways in which the interest of the men may be developed. The bonus system may be introduced in some suitable form and additional payments made on the basis of the number of calves born, or the number of cows attaining yields of 10,000lb. of milk per annum or lactation period, or on the total output of milk. There are objections, however, to giving a bonus in connection with the usual duties of the cowmen or milkers. A good man should not and does not require special payment as an inducement to give a calving cow special attention, and where bonuses have been paid on a milk yield basis instances have been known of the records having been inflated. At the same time the bonus system may be most helpful in some instances, for example, in the production of graded milk, where the amount of the bonus can be made dependent on the bacterial count. Success in clean milk production depends primarily on the manner in which the routine work of washing and sterilizing utensils, cleaning cows and milking is carried out, and as the degree of efficiency in this work is determined by the bacteriological content of the milk, a bonus payable on such a basis is only paid when there is independent evidence that a high standard of work has been attained.

The introduction and development of milk recording has done much to improve herd management and to make the twice daily task of milking more interesting. The daily or weekly weighing of the milk institutes a measure of progress and a basis of comparison which was previously lacking, and on many occasions the writer, when doing milk recording work, has been struck with the interest shown by the milkers in the yields of different cows. Any suggestion which might mean an addition to the number of milk recording forms issued under the Ministry of Agriculture's scheme can only be made with great reluctance but nevertheless a card, which should be kept in the cowshed, so ruled as to show the amount given each week and the total to date for each cow in the herd would be a handy record for the owner and would be greatly appreciated by the men. In many cases the milker knows the highest

daily yields of the cows he milks, but is never informed of the total yield in a year or lactation period.

In respect of feeding much can be done by the farmer in selecting the kinds and quantities of foods which will give a suitably balanced ration, and in a system of feeding in relation to milk yield, but the giving of the allowances of concentrates, etc., at each meal must be left to the cowman, and in the case of heavy milking cows there are times when it is most important to have a man who knows when to depart from the usual system ; in other words, the man who actually feeds the cows has as much need for knowledge of the composition and effects of the different foods as the man who grows and buys them. Much can be done towards supplying this knowledge by distributing the Ministry's leaflets and Agricultural College bulletins on foods and feeding, but attendance at a lecture or course of lectures is much to be preferred. On several occasions when arranging the time of a lecture on the feeding of dairy cows, the writer has been asked to agree to an hour which would permit of the attendance of the cowmen as well as farmers, and such meetings have invariably been well attended and followed by acute and interesting discussions. There is room for a wide development of this principle. The great majority of herdsmen and milkers are truly interested in their work, and a more extensive co-operation between the farmer and the county agricultural education authorities with a view to providing short courses of instruction in dairying districts on such subjects as rationing of dairy cows, secretion of milk and milking, cleaner milk production and first-aid treatment in common diseases, particularly of the udder, will be very much appreciated and cannot fail to give the men a more intelligent understanding of their work and ensure better management of the dairy herd.

Management in relation to Sale.

Milk. The chief product which the dairy farmer has for sale is milk, and the method of sale is to a great extent governed by the position of the farm in relation to a market. Where the farm is situated close to a large centre of population there are two alternatives : (*a*) to sell by retail direct to the consumer ; (*b*) to sell wholesale to a retailer. Where the former method is adopted the farmer gets a higher price because he undertakes the work of distribution as well as that of production, and should get a profit on both branches. On the other hand the distribution of milk direct to the consumer's house requires great attention to detail, and may well be quite as worrying as the management of a herd of dairy cows. Provided that the farm is in a suitable position for the development of a retail business, it may well be that the deciding factor is the temperament of the farmer himself. To many it is sufficient to undertake the production side of the industry, and be content with the producer's profit ; to others, including those in whom the business instinct is more highly developed, the probable extra profit is a deciding factor, and they undertake the labour and worry of the distribution side of the business in order to obtain this extra return.

Where the farmer is also a retailer he should make a study of the practical details of this business, including the organization of delivery rounds to save as much labour as possible, the handling of milk to ensure uniform quality, the best mode of delivery—whether from a churn or by can or bottle—and the washing and sterilization of all utensils to avoid the delivery of milk which will sour quickly. In addition he must master the art of maintaining good relations with his customers, and be ever on the look-out for new ones. If the supervision of these details cannot be undertaken by the farmer himself he must employ an efficient manager who will be able to hold his own in competition with the man who is a retailer only and who is therefore able to devote his whole time to this work.

Generally, however, the dairy farmer is not a retailer of his own produce; he sells his milk wholesale because the distance of his farm from a market leaves him no other practical alternative, or he makes it into cheese or butter on the farm. The price he receives is of paramount importance, but he has also responsibilities in the milking of the cows and handling of the milk, and the manner in which this work is done has a direct bearing on the trade value of the milk itself. No one will contend that milk which goes sour within twelve or twenty-four hours is worth as much either to the distributor or the consumer as milk which will keep sweet for forty-eight hours or more, and it is therefore the business of the farmer to take all practicable precautions to produce a wholesome and good-keeping milk. The distributor and the householder must share the responsibility for the condition of milk up to the time it is used, but undoubtedly the farmer must take the first steps, which consist in seeing that the cows are cleaned before milking, that the utensils through which the milk passes are clean and sterile, that the milking is done in a cleanly manner, and that the milk is immediately cooled to as low a temperature as possible and kept cool and protected from heat and dust before and, if delivered by the farmer, during conveyance from the farm. Much study has been devoted to the handling of milk on the farm in recent years[1] with a view to discovering the simplest and most effective methods, and the latest information is easily obtainable on application to the agricultural educational authorities in each county, or the nearest agricultural school or college.

With regard to price, often there is little that the individual farmer can do to obtain a higher figure. The distribution of milk covers such a large series of operations from the farm to the consumer, and the quantity to be dealt with is so immense and yet so fluctuating, that large wholesale or retail organizations have grown up to undertake this phase of the business, and as these farms have also to deal with the seasonal surplus milk they are in a very strong position when negotiating on prices with a single farmer. The only way in which a farmer can hold his own is by co-operating with other farmers who also have milk to sell, and much has been done in this direction by the National Farmers' Union. The scheme of prices and

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[1] *Min. Agri. London, Mis. Pubn.* No. 41.

quantities agreed on by the Committee composed of representatives of this Union and of all the distributors' organizations has proved quite workable and has helped greatly to stabilize the industry during the last two years.

Farmers must always remember, however, that the distributive or manufacturing sections of the industry will not purchase more milk than they can dispose of at a profit, taking one year with another, and that the fixing of a price by agreement for the country as a whole with modifications according to areas, does not necessarily mean that there is a market for every individual farmer's milk. Milk production is undoubtedly increasing throughout the country: the purchase and use of milk by the public must also increase, otherwise many producers may find that milk of the cleanliness and keeping quality which they produce cannot find a profitable market. It would appear, therefore, that it should be part of the practical farmer's policy to do all he can to increase the consumption and use of milk, and to take great care that the milk he himself produces is such that the purchaser will wish to drink and use more of it.

There is also the possibility of producing a higher grade milk which will command a higher price. Since 1915 licences to describe milk by special designations have been obtainable from the Ministry of Food, and later from the Ministry of Health, and the possessors of these licences have as a rule obtained a higher price for their milk. The question at once arises, "Is the increase in price sufficient to meet the increase in cost of production involved in complying with the regulations under which such licences are granted?" In many instances the answer is undoubtedly—Yes. There is also an increasing amount of evidence that where, in order to obtain a Grade A (Tuberculin Tested) Licence, or a Certified Licence, an owner has eliminated all cows and heifers in milk which react to the tuberculin tests, the standard of health is definitely raised in the herd as a whole and losses are materially lessened.

Cheese and butter. Where the milk is made into cheese on the farm, the sale of the cheese is in the hands of the farmer. The price obtainable for English hard-pressed cheese is, however, influenced by the price of imported cheese, and where the home-made product is of second class or inferior quality it is increasingly subject to very keen competition. The choicest qualities of the well known English varieties have always commanded good prices, and will continue to do so; it appears obvious, therefore, that the farmer who makes cheese should do all he can to maintain and improve the quality of his product and also join with others interested in this branch of the industry in making known to the public the merits of English cheese, so as to increase the demand. It must, however, be recognized that advertisement will do more harm than good, unless the high quality and uniformity of the product can be assured.

In respect of butter, it is estimated that 32 per cent. of the milk produced in Great Britain is used for butter making, but there is no doubt that in many districts this

course is followed in order that the separated milk may be available for the raising of stock, rather than for the direct returns received from the sale of the butter. Numerous private dairies make butter of the highest quality which is disposed of at a satisfactory price, but farm butter as a whole is so varied in colour, flavour and keeping qualities that it cannot have more than a local market. Where the quantity of milk to be made into butter is sufficient to provide a regular supply winter and summer, and no other outlet for the milk is available, then every effort should be made to produce butter of the best quality and to find a market amongst those who are prepared to pay an adequate price for a first-class home product.

Surplus Stock.

Little can be written which will help farmers in the sale of animals which are depreciating in value, and there are usually a few such in every dairy herd. On many farms where a breeding dairy herd is kept, however, it may well be worth while to rear a large proportion of the heifer calves, partly in order to have a larger number to select from for maintaining the herd and partly because there is usually a good demand for dairy heifers, either when fit for service or down calving. Surplus stock of this sort may be a valuable source of income, and if the milk records of the dam and sire's dam are good enough to be published, then the market price of good animals is further enhanced. There is also a steady demand for in-calf heifers and young cows which have passed the tuberculin test, and when animals of the right type and breeding are to be sold, their market value will be increased if they are offered for sale with certificates that they have passed the tuberculin tests required by the Ministry of Health for entry into Grade A (Tuberculin Tested) and Certified Herds.

Conclusion.

The chief practical aim of the dairy farmer was defined at the commencement of this article as the obtaining of the largest average net profit over a period of years. It was pointed out that this end can only be attained by good-all-round management in respect of purchases and sales, in utilization of the land and other raw materials for production, and in the organization of labour. Many points in such management have been discussed in detail above. It is now only necessary to emphasize that this does not mean a conservative stay-at-home policy. Interest, enthusiasm and personal attention to principles and occasionally some details on the part of the farmer himself are essential to good management, but it is also desirable that the farmer should take a judicious share in the farming activities of his district and in the work of the local Agricultural Society and the County Milk Recording Society; he should also visit experimental farms and well-managed farms in other districts to see the methods which have brought success or failure there. In times like the present old methods must be reconsidered, new methods and suggestions studied and perhaps given a trial, and an open and inquiring mind must be joined with a determination to succeed.

NOTES.

RAISING DAIRY CALVES FOR HIGHER PRODUCTION.

How to increase the low production of milk in India is a very great problem before the dairymen of India. Not many of the average farmers know the principles and methods of raising heifer calves for a higher production. If we compare the average production of our cows with the production of the cows in the United States of America or other countries on the globe, we will be looking with surprise. Now, just for an example, the Nebraska College of Agriculture (U. S. A.) has developed a number of cows that have produced at least 22,000 lb. of milk and over 1,000 lb. of butter-fat per year. What makes it possible ? There are two answers for this question. The first is, use better and pure-bred herd sires, in the second place raise only the best heifer calves.

Now the question that may arise is how to raise the calves, and know if they are the best or not. In order to select the most desirable calves, it is essential that production records be kept for each cow in the herd. These records should include the amount of milk and butter-fat produced and the amount and cost of feed consumed during the calendar year. Fairly accurate records may be obtained by weighing the feed and milk during one day of each month and by testing a sample of milk from both milkings of that day for butter-fat by the Babcock test.

Should you raise twin calves ? Yes, if both the calves are of the same sex ; if not, the female is usually sterile. It is a proven fact that it is not profitable to raise twin calves for dairy purposes.

You should separate the calves from their dams within 20 or 24 hours of birth. In case of very high producing cows, remove the calves within twelve hours, otherwise there is always danger of scouring.

If the calf is not able to drink, that is, does not know how to drink, then do not feed it anything, let it get hungry. Hunger alone will teach it how to drink. Feed a small quantity of the mother's milk at as nearly body temperature as possible. Patience and perseverance are necessary in teaching a calf to drink. One way of teaching the calf to drink is to moisten your fingers and let it suck. A few minutes later remove your fingers from its mouth. Do not force the calf's head in the pail and hold it there, for it will choke the calf.

Feeding whole Milk.

Whole milk is the natural feed for young calves and contains all the elements necessary for their growth. If you want to be a successful calf raiser, then feed the calves whole milk until they are able to get nourishment from some other feeds.

This will show that it is necessary to feed whole milk until the calves are about three or four weeks old.

It is a good plan to feed the calf milk from its own dam for three or four days. Later feed mixed milk of the herd. The amount of milk fed varies according to the weight of the calf; about 1 lb. of milk to each 10 lb. of live-weight is sufficient. If you feed the calf three times a day, then feed a little more milk, but be careful not to overfeed. At the end of the period of three weeks, if skim milk is not available, feed a small amount of whole milk supplemented by grain and hay. About 1 lb. of milk for each 8 lb. of live-weight is sufficient until the calf is 4 or 5 weeks old. At that time, if the calves are consuming a good amount of grain and ration, the milk may be reduced at the rate of 1 lb. per day at the beginning of each week.

When the amount of milk is reduced, replace the amount with warm water. It is necessary to feed sufficient milk in order to keep the calves in good growing condition. Generally the amount fed to a calf should never be less than 450 lb.

Feeding skim Milk.

Skim milk is the most satisfactory supplement to whole milk for calf feeding. Calves fed skim milk do not become as fat as those raised on whole milk; they make a vigorous, sturdy growth of body and frame. It is not absolutely necessary to feed some high protein feed when whole milk is replaced by skim milk.

Skim milk may be gradually substituted for whole milk as soon as the calf is able to get some of its nourishment from hay and grain. It is advisable to teach the calf to eat some legume hay at an earlier age, because the leaves of these plants contain growth-promoting elements similar to those found in butter-fat. The amount of skim milk to be fed is determined in the same manner as suggested for whole milk.

If calves over 6 weeks old are fed sour milk, they show good results. To feed it successfully care must be taken that the milk is freshly soured and is not several days old. It is absolutely necessary that the temperature of the sour milk fed should be uniform at all times.

A suitable Grain Mixture.

Grain is a cheaper feed than whole milk. Calves less than a month old will eat grain more readily if it is finely ground, but older calves like coarser feeds. Calves under three months old will usually not overeat if fed grain from a self-feeder. Older calves should be fed grain in limited amounts, 3 to 4 lb. daily being sufficient for calves 3 to 6 months old.

A good grade of fine stemmed legume hay should be kept in a feed rack where the calves have access to it. As soon as the leaves and finer portion of the hay have been eaten, the remainder should be removed and fed to other animals in the herd and a fresh supply substituted. When calves are three to four weeks old they will begin to eat hay in some quantity.

Success in raising calves depends upon the caretaker. Regularity and attention to the details in the feeding and care of dairy calves are very essential because the character of the growth obtained measures the value of the animal when mature.

Warm, comfortable quarters are just as necessary as correct feeding. Calves must be protected from cold drafts and dampness, supplied with fresh air and allowed to exercise.

Fresh water should be supplied to the calves over a month old. A small amount of salt should be given to the calves two to three months old. A little salt may be sprinkled in the feed trough or it may be kept in a box to which the calves have access whenever they desire.

Cleanliness is absolutely necessary. Pails, feed troughs, and racks from which the calves are fed, and the pens, yards and the calves themselves should be kept clean at all the times. Feed must be in good condition and utensils must be kept in sanitary condition if the health of the calves is to be protected. Clean, comfortable pens supplied with plenty of dry bedding are one of the best preventives of disease. [YESHWANTRAO P. BHOSALE.]

MANUFACTURE OF SUGAR DIRECT FROM CANE IN INDIA.

TWENTY-THREE factories making sugar direct from cane worked in India during the season 1923-24 as compared with 19 in the season 1922-23 and 18 in 1921-22. Eleven* of these factories are situated in the province of Bihar and Orissa, 8 in the United Provinces of Agra and Oudh, 2 in Madras and one each in Assam and Bombay. Enquiries were instituted by the Sugar Bureau to ascertain the output of these factories, and we are much indebted to the management of these factories for their courtesy in furnishing the statistics required under various heads.

The table below shows the total amount of cane crushed and sugar made by the factories in (1) Bihar and Orissa, (2) United Provinces and (3) other provinces of India. The production of sugar direct from cane by modern factories in India totalled 1,044,855 maunds or 38,312 tons during the season 1923-24 as compared with 651,415 maunds or 23,886 tons in the season 1922-23.

Provinces	Cane crushed in maunds		Sugar made in maunds		No. of factories working	
	1922-1923	1923-1924	1922-1923	1923-1924	1922-1923	1923-1924
Bihar and Orissa . .	4,770,721	6,738,391	377,292	509,547½	9	11
United Provinces of Agra and Oudh.	2,461,397	5,258,728	171,272	368,790½	6	8
Other Provinces of India .	1,423,256	1,996,917	102,851	166,517	4	4
TOTAL FOR INDIA .	8,655,374	13,994,036	651,415	1,044,855	19	23

*One factory in Bihar did not furnish the required figures.

A study of the statistics will show that there was an increase of 5,338,662 maunds in the quantity of cane crushed and of 393,440 maunds in the amount of sugar produced by factories in India during the season 1923-24 as compared with 1922-23. This increase in all the provinces was due mainly to the fact that factories could obtain more cane for milling in the season 1923-24. It may be mentioned here that, in the season 1923-24, the area under sugarcane in India was 169,800 acres greater than in the previous season.

If we take the all-India figures we find that 13·39 maunds of sugarcane were required in the season 1923-24 to produce one maund of sugar as compared with 13·28 maunds required in the previous season. This was due to the fact that some of the factories in the United Provinces were so overwhelmed with cane that they had to put it through the mills much faster than usual in order to take off this crop.

During the season 1923-24, India's production of molasses by modern factories making sugar direct from cane totalled 622,473 maunds as against 348,024 maunds in the previous season. The increased production should naturally result in a reduction to that extent of the imports of foreign molasses into India unless consumption shows an increase in this country.

Statistics regarding the production of refined sugar by modern refineries in India are being collected and will be published in due course. [WYNNE SAYER.]

REFINING OF INDIAN *GUR*.

IN the Report of the Indian Sugar Committee of 1920 we read that "*gur*, *gul* or *jaggery* is cane juice concentrated to solidification without purification, except the addition of a small amount of alkali and the removal of scums. In India, 99 per cent. of the sugar made is *gur*."

Since the sugar production in India is more than three million tons per annum, the above statement means that, even to-day, nearly one quarter (23½ per cent.) of the total cane sugar production of the world is obtained in the crudest possible form. All of this *gur* is of course consumed locally, and mostly in the crude form in which it is originally produced, but a certain - and increasing—amount is refined in order to obtain a higher grade sugar.* The conditions in India are not generally favourable to the operation of large factories producing a high-grade white sugar direct from the cane, and it appears to be very probable that *gur* refineries will be fully as important as sugar factories during the next decade. Moreover, since *gur* will keep, the sugar factories, with the addition of a comparatively small amount of machinery, can be used for *gur* refining during the off-season.

* For 1922-23, about 3 per cent. of the *gur* produced in India was treated in the *gur* refineries, the output of sugar from this source being more than double that from the cane factories.

Although a certain amount of acclimatized tropical cane is grown in India, practically the whole of the cane *gur* is produced from the indigenous Indian canes ; owing to the great variety of these, and the crude and varying local methods of production, the composition of *gur* is exceedingly variable, which adds very considerably to the difficulty of treating it in a *gur* refinery.

In general, the sucrose content is fairly high, but it is accompanied by an excessive proportion of glucose, organic impurities, and ash, so that the purity is low, and it is by no means a simple matter to produce a high-grade sugar direct from *gur*, on a commercial scale. As the *gur* is made in direct-fired pans, burned or caramelized *gur* is not at all infrequent, and this adds considerably to the difficulty of refining.

In addition to the *gur* from cane juice, there is an actually large, although relatively small, amount of *jaggery* produced from the liquor tapped from certain date palms, and this is usually even more troublesome to refine than is the *gur* from the indigenous sugarcane.

The quality and condition of *gur* vary to such an enormous extent that definite estimations are quite impossible, and a refinery designed nominally to deal with a certain amount of *gur* may actually deal with 50 per cent. less or more—the former being the usual experience.

Most of the existing *gur* refineries have been built up gradually ; there is usually but little technical control, and technical information on the subject is conspicuous by its absence ; even *gur* analyses are not readily available, and are usually very incomplete.

A consideration of over 20 analyses of *gur* from different parts of India shows that the sucrose content varies from 62 to 87 per cent.; the glucose from 5 to 20 per cent.; the moisture from 5 to 15 per cent.; and ash up to 6 per cent. or even more. As the result of a careful study of available data from various sources, the writer considers that a fair average analysis of *gur* is :—

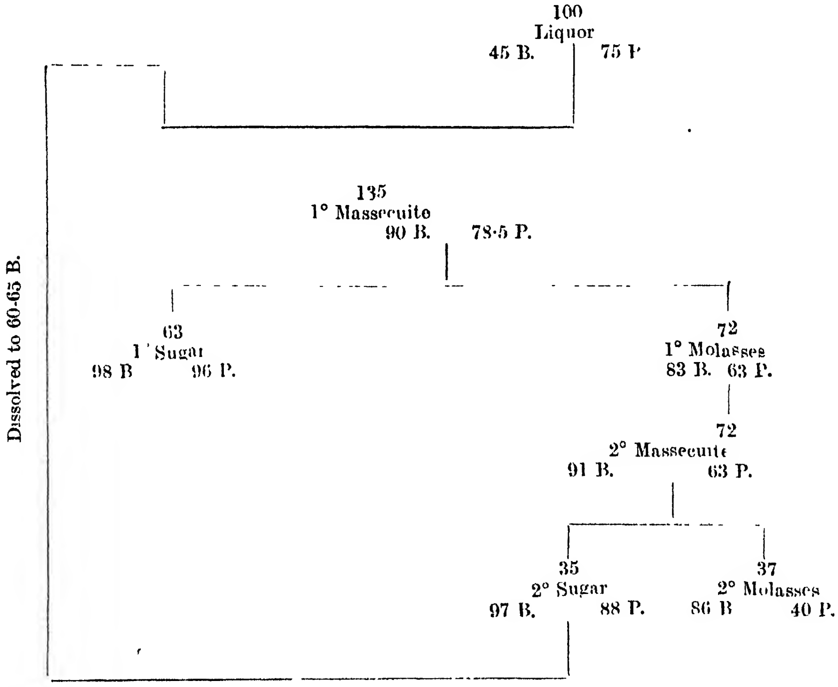
	Per cent.
Sucrose	67
Glucose	15
Other soluble organic matter	8
Water and insoluble matter	10
TOTAL	100

so that approximately, the average *gur* may be taken as 90° Brix. (per cent. solids) of 75 per cent. purity and 22 glucose ratio. As before mentioned, the variations in practice are very great indeed, but the above figures appear to give a reasonable average.

The simplest method of *gur* refining is of course merely to dissolve, clarify with lime and heat, filter to remove the mechanical impurities, crystallize *in vacuo*, and

separate the crystals in a centrifugal, the result being roughly equivalent to the second sugars obtained in an ordinary defecation factory, which is all that can be expected from a simple treatment, since the dissolved *gur* is usually but little better than an ordinary first molasses. For a rough approximation, 100 lb. of *gur* of the average composition mentioned above, when treated in this simple manner, may be expected to give about 45 lb. of sugar of 94° purity,* and 55 lb. of molasses of 55° purity, which would be marketed as such.

Much of the colouring matter may be bleached by a single sulphuring, giving a higher grade of sugar. The molasses may be boiled for a second sugar, which is redissolved and returned to the liquor, as indicated by the accompanying diagram; in this case we may expect to obtain roughly 56 lb. sugar of 96° purity† and 40 lb.



B = Brix. P = Purity. Quantities refer to solids.

molasses of 40° purity from 100 lb. of *gur*. In some cases, depending on the composition of the liquors and the plant capacity available, the exhaustion may be made in

* 42-43 per cent. is the usual recovery, of perhaps a slightly higher purity.
† The usual recovery is from 52-53 per cent. in Northern India to 57-58 per cent. in Southern India.

three stages, the third massecuite being boiled high, left in concrete tanks for a few weeks, pugged and centrifugalled and finally re-dissolved and returned to process.

The 96° sugars may be raised in purity by washing in the centrifugals, or by double curing, with, of course, a corresponding amount of dissolved solids returned to process for further refining. With the higher grade *gurs*, a satisfactory sugar of 98-99° purity can thus be obtained, which will be nearly white providing proper attention has been given to the sulphuring. With the lower grade *gurs*, and especially those from date-palm juices, if a 99° purity white sugar is required, practically the only method is first to recover as much sugar as possible at something over 90° purity, with a preliminary sulphuring of the liquor ; then to re-dissolve, lime and sulphur to whiteness, filter, re-crystallize, etc., as best white sugar.

For the highest grade of refined white sugar, the liquor is, of course, filtered through bonechar, but in India the laws of caste generally preclude the use of this process for sugar intended for consumption by Indians, so that the sulphitation process is usual. India would appear to offer a favourable field for the use of vegetable carbon for decolorizing purposes, if the cost can be brought down to compare with that of sulphitation.

In many parts of India, a white sugar, finely pulverized, is very highly esteemed; and when this is to be made, the size of the grain formed in the vacuum pans is not of vital importance, so long as it is large enough to be retained by the centrifugal gauze. Even with the fine powder, uniformity of size of the particles is of importance ; the sugar must be properly dried, and then pulverized in high grade 4-roller pulverizers, with accurately ground rollers and micrometer adjustments, exactly similar to those used for flour milling. [P. H. PARR in *Int. Sugar Jour.*, Vol. XXVI, p. 532.]

THE CONTROL OF THE COTTON WEEVIL.

FIND what it is in the cotton plant that the boll weevil likes ; produce it in marketable quantities ; bait traps with it or mix it with poison, and so lure the insects to their destruction. That is the skeleton of the idea on which scientists of the U. S. Department of Agriculture are working.

When the weevil comes out of its winter sleep, in the vicinity of a cotton-field, it somehow knows enough to make a bee-line for its natural home. It will sometimes travel considerable distances to reach growing cotton if there are no plants near at hand.

Dr. Frederick B. Power, the leading biochemist in the Bureau of Chemistry, with the co-operation of V. K. Chesnut, of the same bureau, is endeavouring to find which of the many complex substances in the cotton plant gives it this peculiar attraction for the weevil and this is a very difficult task. Large quantities of cotton plants have

been subjected to steam and distillation processes, and the substances isolated tested for their power of attracting boll weevils. This part of the work falls to the Bureau of Entomology, where workers watch the behaviour of the insects toward the various substances.

Dr. Power states, with the characteristic caution of a thorough scientist, that he is "making progress," but will not make a direct claim that the problem has been solved. The results of the investigation will be announced to the scientific world and to the public in due time.

This new attack on the boll-weevil problem may well become the pioneer work in a wholly new departure in the study of the relations between plants and the enemies that attack them. There are many other insects that show a similar preference in the choice of the plants they feed on. Potato beetles, for instance, confine their diet chiefly to potato plants; the Hessian fly commonly attacks nothing but two or three kinds of grain. In all such cases, there must be some definite attraction exerted by the plant, some specific substance that appeals to the insect so strongly that it will turn from all other things to seek it. If such substances can be isolated and used as baits loaded with poison, or placed in insect traps, or set over pans of water or oil, or in other ways utilized to lure insect pests to their doom, another step will have been taken in the solution of the crop pest problem. [*Science*, N. S., Vol. LX, No. 1554.]

DEVELOPMENT OF MANLESS PLOUGHS.

READING that is almost fascinating in its interest is contained in a paper that was contributed, says Chicago *Farm Implement News*, at a meeting of the American Society of Agricultural Engineers, and in which mention was made of the fact that two agricultural engineering students in the United States had built ploughs of the "manless" type. One of the manless ploughs consisted of a two-wheel tractor with a four-h.p. single-cylinder engine to provide the power. Right and left hand plough breasts were attached to the frame, had their beams opposite and nearly at right angles to the tractor axle, and were so placed that while one was in work the other was carried above the ground surface. In operation the outfit was steered by hand for the initial furrow, after which the first furrow served as a guide for the plough. The success of the plan was fully demonstrated, for a driving wheel will only rarely leave a furrow wall and the furrow does not need to be particularly deep to control a plough in this manner. The machine travelled back and forward in the shuttle style. A reversing arm or antenna hung over the tractor and extended out some distance beyond the machine in each direction. This reversing arm, upon coming in contact with a fence or other obstruction, was pushed back to a point where spring action came into place and reversed the direction of the driving mechanism. The reaction immediately lifted the breast in work out of the

ground and swung in the other one, a proceeding that took place quite smoothly and positively. One problem in connection with the operation of the machine was that of moving the tractor over across the direction of travel the width of one furrow each time the machine was reversed. This was secured by causing the driving wheel on the ploughed ground side of the tractor to make a part of a revolution with the driver on the unploughed part acting as a pivot. It was found that to put a machine of this kind into actual service some safety devices would be necessary, such as making provision for the stopping of the engine should the plough leave the furrow. The inventor has worked out a simple means of doing this.

The second manless plough was the result of the study of a machine with a stationary motor using cables. This machine consisted of a skid carrying an electric motor and reels for the main cable used in drawing the implement to and fro across a field, an anchor skid upon the opposite side of the field carrying a pulley, reels on the motor skid for moving the power skid and anchor skid forward at the precise time, reversing mechanism to the motor and intermittent drive to the reels for moving the skids. The mechanism for moving the power and anchor skids was one of the most ingenious parts of the machine. This device moved the skids alternately every time the motor was reversed by taking in cables attached to the anchor at the corners of the fields. The skids were held in place by one runner following a furrow. It is suggested that when such an outfit has been thoroughly tried out and perfected there is no reason why it should not work continually for a 24-hour day.

THE WORLD'S WHEAT SUPPLIES AND REQUIREMENTS.

The following survey of the position as regards the world's available supplies and requirements of wheat has been published by the International Institute of Agriculture in its October International Crop Report.

Exportable Surplus.

The quantity of wheat which, in theory, was exportable from the five chief exporting countries at the beginning of August, may be estimated at 122½ million centals* from Canada, 148 million from United States, 23½ million from India, 25 million from Argentina, and 7 million centals from Australia, thus aggregating about 326 million centals.

Exportable surpluses probably existed at 1st August 1924 in other countries, particularly in Balkan lands, in Hungary, Manchuria, Chile, and Uruguay. No basis for estimating the quantities available in these countries is discoverable, so that only a rough estimate is possible, which would place the aggregate figure of

* 1 cental = 100 lb.

exportable stocks in these countries at 18 million centals on 1st August, 1924. Russia exported some millions of centals of wheat last year, but can scarcely be expected to do much this season in view of the deficient crops in that country. In favourable seasons Algeria and Tunis take their place amongst exporters, but this year's poor crops may constrain them to import wheat.

To sum up, the quantity available for export at 1st August may be taken at about 344 million centals. At the beginning of 1925 this quantity will be reinforced by the exportable surpluses from the new crops of Argentina and Australia, now well advanced in growth. According to the most recent advices, prospects are satisfactory in both these countries, so that, taking into account the slightly increased areas sown in each of them, it may be expected that their aggregate yield will not fall below that reaped last year, which amounted to about 220 million centals. Inasmuch as their aggregate consumption is about 70 million centals, it may be hoped that the quantity of wheat harvested in Argentina and Australia will allow of an exportable surplus of 150 million centals.

If this new supply of 150 million centals is added to the 344 million centals which were available at 1st August 1924, an aggregate exportable surplus of 494 million centals is reached, available during the period between 1st August 1924 and 31st July 1925.

By way of comparison, the subjoined figures show the quantities which, in theory, were available between 1st August and the subsequent 31st July, and the quantities actually exported during those periods, for the three years preceding the current season.

	Quantities exportable	Quantities exported
	(Million centals)	
1924-25	494	–
1923-24	570	487
1922-23	500	429
1921-22	471	415

The quantity available for export during the current season appears to be less than that during 1923-24 by fully 75 million centals, and is only slightly larger than the actual exports of that year. On the other hand, the quantity is about equal to the exportable surplus of 1922-23, and is larger by 65 million centals than that actually exported in the last mentioned season.

Requirements of Importing Countries.

Any estimate of the probable requirements of the importing countries has even more elements of uncertainty than are involved in ascertaining the surplus available in exporting countries.

A comparison of yields and importations during the twelve months subsequent to the harvests shows that in the seasons 1921-22, 1922-23 and 1923-24 (omitting data of stocks at the opening and close of each season) the *apparent* consumption of the chief importing countries was subject to considerable fluctuation varying from 881 million centals in 1921-22 to 793 million in 1922-23 and to 927 million in 1923-24. Although the yield in these countries in 1922 fell short by about 100 million centals of that in 1921, their importations during the season 1922-23 hardly exceeded those of the corresponding period in 1921-22. Per contra, with a yield in 1923 of about 90 million centals greater than in 1922, imports during the season 1923-24 reached a quantity of about 50 million centals more than that of the same space of time in 1922-23.

Such fluctuations may be partly explained by the fact that the actual consumption has a tendency to increase in plentiful seasons, and to decline when harvests are scanty, but augmentations and reductions in stocks are also contributory factors. Doubtless these stocks were larger at the outset of the 1921 season than they were a year later, and less important at the beginning of the season 1923 than they had become at the like period in 1924.

Hence, the *apparent consumption* during a season, obtained by adding together the yield of each respective year and the imports during the twelve months subsequent to harvest, must be considered to be *below the actual consumption* in a season of deficient crops, when stocks tend to diminish, and *above the actual consumption* in a plentiful season, when stocks are on the increase. With special regard to the imports during the season 1923-24, it must be especially noted that the Far East absorbed unusual quantities, and Japan, after the earthquake, was a very large importer.

Taking these points into account, it may safely be assumed that, while the yields in the chief importing countries in 1924 were lower by about 60 million centals than those in 1923, the import requirements during the season 1924-25 would not be likely to outweigh by any corresponding quantity the importations from 1st August 1923 to 31st July 1924.

Adopting as a basis of comparison the position evolved during the season 1922-23, when the yield was below that of 1923, and yet the importations fell short by about 50 million centals of those which took place during the season 1923-24, it may be expected that the requirements during the twelve months after the harvest of 1924 will be less than the quantity imported in the past season. However, considering the poor quality of the new wheat in several countries of Europe and the generally deficient crop of rye (an important alternative food grain in some regions), it seems more prudent to admit theoretically that the aggregate requirements of importing countries between 1st August 1924 and 31st July 1925 might prove equivalent to their imports in the like period of last year, totalling about 485 million centals.

Summary of the Position.

On the one hand the quantities available for export during the season 1924-25, estimated at about 494 million centals, and on the other hand the probable requirements of importing countries during the same period, are placed in juxtaposition. These requirements cannot be precisely defined, but with the experience of the past seasons and consideration of the points already mentioned, they may fairly be stated at 485 million centals. The outcome is that the available supply is in close correspondence with the requirements, and allows only a narrow margin, a result differing greatly from those in recent seasons. In fact, although the situation of the wheat supply need not give rise to anxiety, it must be admitted that it is far from being so favourable as in late years, when the available supply largely exceeded the probable requirements.

It might be as well to add that, with the rise in prices, consumption may fall short of the forecasted figures; and in that case some stocks of old wheat will remain on hand at the close of the current season. It must, however, be remembered that estimates of yield are still only preliminary and may have to be reduced later, while it has to be emphasized that the new crops of the southern hemisphere may afford results less favourable than those forecasted at present. If this should happen, there might be danger of absence of equilibrium between the supplies of wheat and the normal requirements.

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

We deeply regret to record the death of Mr. F. T. T. Newland, late Government Agricultural Engineer, Madras, who left the Department on proportionate pension only a few months ago.

Mr. R. B. Ewbank, C.I.E., I.C.S., Deputy Secretary to the Government of India, Department of Education, Health and Lands, has been granted combined leave for 10 months and 16 days from 11th March, 1924. He was placed on deputation as Secretary to the Colonies Committee from 12th March to 23rd July and 4th to 6th August, 1924, and consumed leave during that period.

Dr. W. H. Harrison, Joint Director, Agricultural Research Institute, Pusa, and Imperial Agricultural Chemist, has been granted combined leave for eight months from 1st March, 1925.

Mr. A. Howard, C.I.E., Imperial Economic Botanist, Pusa, has been appointed Director of the Institute of Plant Industry, Indore, and Agricultural Adviser to States in Central India.

Mrs. G. L. C. Howard, M.A., Second Imperial Economic Botanist, Pusa, has been appointed Physiological Botanist, Institute of Plant Industry, Indore.

Mr. E. Shearer, M.A., B.Sc.; formerly Imperial Agriculturist, Pusa, has been appointed Principal, East of Scotland College of Agriculture, Edinburgh.

Mr. E. Ballard, B.A., formerly Government Entomologist, Madras, has been appointed Cotton Entomologist, Queensland.

Mr. G. R. Hilson, B.Sc., Cotton Specialist, Madras, has been appointed to officiate as Director of Agriculture, Madras, *vice* Mr. R. D. Anstead granted leave.

Mr. D. Balakrishna Murti Garu, Professor of Agriculture and Superintendent, Central Farm, Coimbatore, Mr. S. Sundararaman, M.A., Government Mycologist, Madras, and Mr. G. N. Rangaswami Ayyangar, B.A., Millets Specialist, Madras, have been confirmed in the Indian Agricultural Service from 29th October, 1924.

Dr. W. Burns, Economic Botanist to Government, Bombay, has been granted leave on average pay for six months from 1st May, 1925, Mr. G. B. Patwardhan officiating.

Captain G. G. Howard, M.R.C.V.S., Deputy Director of the Civil Veterinary Department, Orissa Range, has been confirmed in the Indian Veterinary Service.

Rai Sahib Priya Nath Das acted as Deputy Director, Civil Veterinry Department, North Bihar Range, from 13th September to 15th October 1924, *vice* Captain P. B. Riley on deputation for training at Muktesar.

The services of Captain J. B. Idle, Superintendent, Civil Veterinary Department, have been placed at the disposal of the Special Officer, Civil Veterinary Department, Burma.

Major R. F. Stirling, F.R.C.V.S., Offg. Veterinary Adviser to the Government of Central Provinces, has been granted combined leave for nine months from 7th November, 1924.

On relief by Mr. J. H. Ritchie, Mr. R. H. Hill, Offg. Deputy Director of Agriculture, Northern Circle, Central Provinces, has been transferred in the same capacity to the Southern Circle, Nagpur.

On relief by Mr. R. H. Hill, Mr. J. C. McDougall, M.A., B.Sc., Deputy Director of Agriculture, Southern Circle, Central Provinces, has been placed on special duty in the office of the Director of Agriculture, Central Provinces.

NEW BOOKS

On Agriculture and Allied Subjects

1. Essentials of the New Agriculture, by H. J. Waters. Pp. viii +549. (Boston and London : Ginn & Co.) Price, 7*s*. 6*d*.
2. Elements of Rural Economics, by T. N. Carver. Pp. v+266. (Boston and London : Ginn & Co.) Price, 7*s*.
3. Soils and Crops, by J. H. Gehrs. Pp. viii+444. (London : Macmillan & Co.) Price, 6*s*. 6*d*.
4. Recent Developments in Cattle Breeding, by G. F. Finlay. Pp. 62. (Edinburgh and London : Oliver and Boyd.) Price, 2*s*. 6*d*.
5. Grapes, Peaches, Melons, and How to Grow them. A Handbook dealing with their History, Culture, Management and Propagation, by T. W. Sanders and J. Lansdell. Pp. 150. (London : Collingridge & Co.) Price, 5*s*.
6. Colour Planning of the Garden, by G. F. Tinley, T. Humphreys and W. Irving. Pp. 324. With 300 drawings in colour by Miss M. Walters Anson. (London : T. C. and E. C. Jack, Ltd.) Price, 42*s*.
7. A Text Book of General Botany, by G. M. Smith, J. B. Overton, E. M. Gilbert and others. Pp. 409. (London : Macmillan & Co.) Price, 16*s*.
8. Researches on Fungi, by A. H. R. Buller. Vol. III ; Pp. 611. (London : Longmans, Green & Co.) Price, 32*s*.

THE following Publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Bulletin

1. List of Publications on Indian Entomology, 1923 (compiled by the Imperial Entomologist). (Pusa Bulletin No. 155.) Price, As. 11 or 1*s*.

Report

2. Scientific Reports of the Agricultural Research Institute, Pusa (including the Reports of the Imperial Dairy Expert, Physiological Chemist and Secretary, Sugar Bureau), for the year 1923-24. Price, R. 1 or 1*s*. 8*d*.

Miscellaneous

3. The Catalogue of Indian Insects, Pt. 5. Nitidulidæ, by S. N. Chatterjee. Price, As. 10 or 1*s*.

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Edited by

The Agricultural Adviser to the Government of India

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HIS EXCELLENCY LORD READING, VICEROY AND GOVERNOR-GENERAL IN INDIA,

ORIGINAL ARTICLES

THE TECHNOLOGICAL RESEARCH LABORATORY OF THE INDIAN CENTRAL COTTON COMMITTEE.

Readers of the " Agricultural Journal of India " are already aware that as soon as they were assured of funds the Indian Central Cotton Committee lost no time in putting into force the recommendation of the Indian Cotton Committee of 1917-18 and of the Board of Agriculture in India of 1919 that provision should be made for technological research on cotton and particularly for the testing of new cottons for Agricultural Departments. Work was started in January 1924 with the arrival of Mr. Turner (recently Professor of Textiles, Manchester College of Technology) who was appointed Director of the Laboratory.

The Laboratory consists of two sections, *viz.*, the Research Laboratory and the Spinning Laboratory. The former is temporarily housed in the Victoria Jubilee Technical Institute ; the Spinning Laboratory has already been completed and work started in July last. Work on the main building of the Research Laboratory will be completed before the next monsoon.

A most interesting function took place in Bombay on 3rd December, 1924, when His Excellency the Viceroy formally opened the Spinning Laboratory, started the machinery and laid the foundation-stone of the Research Laboratory. We publish below His Excellency Lord Reading's speech and also the speech of the Agricultural Adviser to the Government of India who is *ex-officio* President of the Committee.

His Excellency, who was accompanied by Her Excellency Lady Reading, His Excellency the Governor of Bombay and Lady Wilson, and the personal staff, was received on arrival by the President, Vice-President and Secretary of the Committee and the Director of the Laboratory. After Their Excellencies were seated the members of the Committee were presented to His Excellency the Viceroy. A large and distinguished gathering of visitors was present at the ceremony including His Excellency the Naval Commander-in-Chief, the members of the Bombay Executive Council, the Minister for Agriculture, Bombay, a number of Ruling Chiefs, representatives of the Chambers of Commerce and Millowners' Associations, several of the Governors of the Indore Research Institute and several representatives of Provincial Cotton Committees.

Dr. Clouston's Speech.

Dr. D. Clouston, C.I.E., Agricultural Adviser to the Government of India and President of the Indian Central Cotton Committee, in requesting His Excellency the Viceroy to perform the ceremony, said :—

" YOUR EXCELLENCY—It is my very pleasant duty and privilege on behalf of the Indian Central Cotton Committee to extend a most cordial welcome to you and to Her Excellency Lady Reading and to express our extreme gratification at the honour which Your Excellency has conferred upon us by your presence here to-day. Your Excellency will perhaps permit me further to express our great pleasure that so distinguished a gathering representing so many interests, concerned directly or indirectly with the cotton industry, has met here with us to honour this occasion—an occasion which, we venture to hope, marks the inauguration of a new era in the annals of India's cotton industry.

" The Indian Central Cotton Committee cannot lay claim to a great age We are still at the stage when the enquiry is frequently heard, who are the Indian Central Cotton Committee and what do they do. On the other hand, the industry which supports us and which has already begun to benefit by our activities has its origin in hoary antiquity. It will, therefore, be of interest if I trace the chain of circumstances which led to our establishment. From very early days cotton has been grown in almost all parts of India. For centuries the cultivator was content to grow the kind of cotton and to follow the methods of cultivation and marketing which were stamped with the seal of long established custom. As time progressed, the development of the textile industry in India and other countries resulted in a greatly increased demand for the fibre. Improved facilities for ginning, transporting and marketing the crop were introduced and a healthy export trade arose. Under the new conditions of trade various abuses crept in, and it became increasingly difficult for the cotton grower to maintain the quality of his produce. His seed got mixed in the factory with that of inferior sorts, and insect pests and fungoid diseases took a heavier toll of his crop.

" Since their inception the Imperial and Provincial Departments of Agriculture have, by giving special attention to the improvement of cotton, done their best to enable him to adjust himself to these new conditions. Improved strains of cotton have been evolved and better methods of cultivation introduced. But the activities of these departments have been restricted both by the need for economy and by the shortage of officers. Their small staffs have, moreover, been occupied in solving a diversity of problems spread over the whole field of agriculture. Much has been accomplished nevertheless within the last twenty years, and the results obtained have, we venture to say, opened up a vista of great possibilities for the development of India's cotton industry.

" Progress has been unduly retarded by the fact that the mixing of good cotton with cotton of an inferior quality is so commonly practised. This is done either

by mixing the two grades as *kapas* before ginning, or as lint before pressing. The result in both cases is the same ; the buyer becomes suspicious of all cotton offered as being of the higher grade and reduces his rates in consequence. In the former case, however, a double injury is done to the cultivator, for it results both in his having to sell at a reduced rate and in his getting mixed and inferior seed for sowing. Incidentally the pernicious practice of mixing also handicaps Agricultural Departments in their efforts to establish superior and uniform types of cotton over large areas.

" A further difficulty with which the departments have to contend is lack of information as to the real spinning qualities of their new cottons ; for the spinners, though always willing to help, are not in a position to give the detailed information required. It thus became apparent that all was not well with the cotton industry in India, and that, unless something were done to remedy matters, the position would gradually become worse. Government realized the seriousness of the situation and in 1917 the Indian Cotton Committee was formed.

" The age in which we live, Your Excellency, is an age of research and research is concentrated experience. It is not surprising, therefore, that among the recommendations made by the Indian Cotton Committee, research on cotton figured very prominently. They recommended (1) that the staff of the Department of Agriculture of each of the cotton-growing provinces should be increased with as little delay as possible, (2) that steps should be taken to stop such abuses as mixing and damping which have done so much to spoil the good name and lower the value of Indian cotton, and (3) that Departments of Agriculture should be brought into closer touch with the trade, and be provided with the means of getting more complete information regarding the qualities of the improved cottons they evolved. It was chiefly with the object of achieving the latter two aims that they recommended that a permanent Committee, to be known as the Indian Central Cotton Committee, should be constituted. This recommendation Your Excellency's Government was pleased to accept and the Indian Central Cotton Committee came into being in March 1921, and was duly incorporated as a permanent body with a definite constitution in May 1923.

" On the Committee we have representatives from all parts of India and from all sections of the cotton industry—from the consumer to the producer. We can truly claim to be an all-India body ; our funds come to us from all parts of India, and the work we have in hand is designed to benefit the industry throughout the length and breadth of this great Empire. It is, therefore, a very happy omen that on this occasion when we are about to embark on one of the main lines of our activity, Your Excellency, upon whose shoulders the cares of all India fall, has graciously consented to mark the event by your presence here to-day.

" And now, Your Excellency, permit me to refer to the work which we, as a Committee, have been able to accomplish during the short term of our existence, and to indicate very briefly what we hope to undertake in the future. We have been able

to advise Your Excellency's Government in regard to three important pieces of legislation, *viz.*, the Cotton Cess Act, the Cotton Transport Act and the Bill for the Regulation of Gins and Presses. Of these, all but the last have received the assent of Your Excellency's Government and been passed into law.

" The Cotton Cess Act makes provision for our legal constitution, and has provided the Committee with a means of obtaining funds for the furtherance of research.

" The Cotton Transport Act has been designed to eliminate, or reduce, the evil of adulteration in those tracts where the practice has arisen of importing cotton waste, or cotton of inferior quality, for mixing with superior grades with a view to reaping an illicit profit. This Act provides for the protection of prescribed areas by making illegal the importation of outside cotton into such areas except under license. The provisions of this Act have as yet been applied only in the Bombay Presidency, where in all 6 areas have been prescribed. Although this Act has been enforced for one season only, we are happy to be able to inform your Excellency that the results have justified our expectations.

" The Bill for the Regulation of Gins and Presses provides for the maintenance in every ginning and pressing factory of records of the cotton ginned and pressed; for the submission of a return showing the number of bales pressed; and for the marking and numbering of bales. This Bill is complementary to the Cotton Transport Act and will provide a check on the mixing of different cottons which are grown side by side in the same tract.

" We have also been able to advise the Government of Bombay in the preparation of the Bombay (District) Markets Bill. The object of this Bill is to provide for the establishment of properly regulated cotton markets, with a view to enabling the cultivator to secure an adequate price for his cotton.

" I have already referred to the fact that the passing of the Cotton Cess Act placed the Committee in possession of funds for the encouragement of research work, directed to the improvement of cotton growing and marketing. With the sanction of Your Excellency's Government the Committee have now adopted a definite research programme, and are working in co-operation with Provincial Departments of Agriculture and other institutions, to which they have made grants-in-aid for the investigation of various scientific problems relating to cotton. The lines of research include the improvement of cotton by breeding and selection, the investigation of fungoid diseases and insect pests, and the study of certain bio-chemical problems connected with the cultivation of cotton. In co-operation with the Durbars of 8 of the Central Indian States, the Committee are also financing a Central Institute for research on cotton at Indore, and have been fortunate in obtaining the services of two very eminent botanists who will control the work there.

" On the technological side, we have arranged to supply the Departments of Agriculture with detailed information as to the spinning qualities of the new types of cotton which they produce. With this end in view we have devised a scheme for

technological research. When this scheme is complete, we shall have two laboratories —a Spinning Laboratory and a Research Laboratory. The first of these has already been completed and equipped with a complete spinning plant and with an exhaustive range of instruments for testing cotton yarn. As these tests can be carried out on small samples, and at an early stage in plant breeding work, we hope to be able to guard agricultural officers against proceeding with a cotton which is of no intrinsic value from the spinner's point of view.

" The Research Laboratory which is in course of erection will be equipped with the necessary staff and fittings to enable a thorough chemical, microscopical and physical examination to be made of each cotton sent for trial. By collating the results obtained in these two laboratories, we hope to arrive at the position when by an examination of certain of the measurable properties of a sample of raw cotton, we shall be able to state fairly accurately how it is likely to behave when spun. We also hope to be able to place agricultural officers themselves in the position to measure some or all of these characters. We consider this line of research as one of the most important of our activities, and we are gratified that Your Excellency has been graciously pleased to mark its importance, by consenting to open one laboratory and to lay the foundation-stone of the other.

" At an early stage it became obvious that one of the great difficulties connected with cotton improvement in India was the shortage of qualified workers with a knowledge of scientific methods as applied to cotton investigations. The Committee therefore decided to give six research studentships annually to distinguished graduates of Indian Universities to enable them to undertake research work on cotton problems under the direction of experienced investigators. In this way it is hoped to build up a corps of qualified workers, and we believe the improvement of this historic industry will provide a worthy career for the young educated Indian who desires to serve his country.

" It will thus be seen that this Committee, which is representative of the various interests concerned with cotton, is carefully considering the place for research in different branches of the cotton industry, and that it has already done a considerable amount of solid work in starting and co-ordinating schemes with that end in view. The main aim of that research is to help the cultivator to help himself by enabling him to produce a larger quantity of cotton of a quality for which the buyer will readily pay a higher price.

" It is the determined pursuit of a common aim, Your Excellency, that has enabled the Committee to produce the results which have already been achieved. We come from many parts of India and represent interests which in the past have been held to be divergent ; but in our efforts to promote the welfare of a great industry, and in particular that of the cotton grower, we have worked harmoniously, and Indians and Europeans, non-officials and officials, growers, traders and spinners have come to know one another and to appreciate each others' standpoint.

"It is difficult to discriminate where all have worked so whole-heartedly to a common end, but it is only right that I should bring to Your Excellency's notice the cheerful way in which our up-country members have faced the sacrifice of time which periodical meetings in Bombay entail. Further, I should like to express my appreciation of the invaluable support which we have received from the cotton trade, and of the generous way in which many business men of high standing have made the work of the Committee their constant care. To their hearty co-operation much of the success we have attained is rightly due.

"The passing of the Act, which incorporated the Committee as a permanent body, we feel to be an expression of the confidence of the Government of India in our usefulness. Your Excellency's presence amongst us to-day gives us a further demonstration of your interest in our work, and inspires us to further effort.

"It is now my privilege, on behalf of the Indian Central Cotton Committee, to ask Your Excellency to open the Spinning Laboratory and lay the foundation-stone of the Research Laboratory."

H. E. The Viceroy's Speech.

His Excellency the Viceroy said :—

"It gives me the greatest pleasure to take part in this inaugural ceremony to-day for several reasons. In the first place I am enabled to express my high appreciation of the value of technological and other forms of research connected with cotton with which this ceremony is primarily concerned ; and in addition there is the wider subject of the activities of the Central Indian Cotton Committee and the general question of the cotton industry in India as a whole in which I take the warmest interest and to some aspects of which I desire to draw attention.

"The Indian Central Cotton Committee lost no time after their formation in carrying out the recommendations of the special Indian Cotton Committee of 1919 regarding the appointment of a technologist and the erection and equipment of a laboratory and experimental spinning installation in which accurate tests can be made and correct judgment concerning the value of varieties of cotton sent for test can be reached. The spinning test represents the main avenue to all technological research in cotton ; and the experimental spinning plant, erected here, now enables the most satisfactory method of ascertaining the value of cotton by actual spinning test to be carried out under expert control. These tests will be supplemented by other scientific processes directed towards classifying the properties of various types of Indian cottons ; and these results will be correlated with the results from spinning tests. Properties of fibre and yarn are also to be investigated. For some of these processes a laboratory will be required where physical, chemical and microscopical examinations can be conducted. A building has been designed and begun

for these purposes ; but meanwhile, thanks to the kindness of the Trustees of Victoria Jubilee Technical Institution, the actual laboratory tests have not had to wait upon the completion of the building and are already being carried out in the premises of the Institution. I need not emphasize the great value of this work. Its effect in assisting in the selection of the most suitable varieties of cotton for growing and in placing facts before the producers and consumers of first importance in the marketing of cottons cannot be over-estimated. I heartily congratulate all those concerned in the successful start made in technological research work here, and I also felicitate the public interested in cotton on the possession of an institution designed for scientific tests which, I am confident, will be of the greatest value in the history of this most important industry.

" It may appear in Bombay unnecessary to dwell upon the wider aspects of the work of which the experimental spinning plant is only part, though a very important part ; for Bombay is the great cotton centre. Not only does the Presidency grow large areas of cotton but much of the prosperity of Bombay City itself is bound up with the cotton industry and large numbers of persons are directly concerned with the purchase, marketing and export of cotton or with the spinning and manufacture of cotton cloth and yarn. The question of cotton supply has accordingly a direct reaction on the general conditions of the financial, commercial and industrial prosperity of this city ; but this lively interest is now universal outside Bombay ; and perhaps in some quarters in India men's minds are apt to dwell in some perplexity on problems of financial stringency and of needs for social, administrative and economic improvements of various kinds without realizing, as keenly as I do and as many, I feel sure, in Bombay also do, that the cure for many of these difficulties and defects lies in increase and improvement of production. The effect of increased production in adding directly and indirectly to State revenues and in enhancing the prosperity of the producer, the manufacturer and the industrial labourers will, I am confident, show the way of escape from many of those difficulties and problems for which at present no easy solution can be found.

" One of the more obvious means of improving production in India lies in concentration on the improvement of the cotton crop. India is vitally interested in cotton. Many parts of the world can produce food-stuffs ; but the favoured areas which have conditions suitable for the production of cotton lints for use for clothing and numerous other purposes are limited. India, however, has the priceless heritage of a climate and soil favourable for cotton production, and it would be madness to neglect or squander that fair inheritance or to fail to use every effort to improve it by wise stewardship. India consumes a large quantity of cotton goods. It has an extensive cotton export trade. It is keenly interested in the manufacture of cotton goods both through well-established and efficient spinning mills, in which much capital has been invested and which give employment to large numbers of workers, and through widespread " cottage industries " which produce large quantities of hand-woven yarn and cloth.

"It must be remembered that India is not only the largest cotton-producing country in the British Empire, but is also the second largest cotton-producing country in the world. Moreover, America, the largest producer, is itself now yearly absorbing to an increasing extent its own produce. For this reason, not only in the interests of India itself, but in the interests of the Empire-supply and world-supply, the cotton industry of India holds a most important position and India offers the greatest possibilities for a considerable increase in the supply of cotton in the near future.

"The possibilities of increase in India lie in various directions. There is the question of the expansion of the area under cotton which is largely connected with the extension and improvement of irrigation and the exploitation of new areas suitable for cotton cultivation. Another aspect of the case is the possibility of securing a better average yield per acre in existing cotton areas by selection and stabilization of the better varieties of cotton or by the introduction of new kinds. There is also the question of the prevention and cure of diseases and pests to which the crop is peculiarly liable and which cause a considerable volume of loss each year. There is also need to study the export and mill demand more closely and to aim at improvements in the production and marketing of the desired varieties in commercial demand for the cotton trade with the mills in India or other countries. This includes the prevention of adulteration, deterioration and admixture and the stabilization of the supply of various types in demand in various markets. As an illustration of the great scope for improvement I may note that the Cotton Committee in 1919 stated in their report that the average yield of Indian cotton was only 85 lb. of lint to the acre as compared with 200 lb. in America; and that there was in addition defective marketing resulting in losses for Indian cotton of 10 per cent. more in the blow room as compared with American and Egyptian cottons. The Committee also found that before the War Lancashire, the best available cotton market, took little Indian cotton owing to the short supplies from India of staple cotton approximating the commercial inch standard.

"The time at my disposal does not permit me to do more than indicate in the broadest manner the great importance of the field open to the labours of the Central Indian Cotton Committee, the immense potential value of the work on which they are engaged and the numerous problems, of which I have only enumerated a few salient points, remaining to be solved by their efforts and advice; but if in my brief sketch I have been able to communicate even in some degree the keen interest which I feel in their work and my deep appreciation of the importance of their labours in the interests of the progress of India and the prosperity and welfare of the people of India, I shall have been amply rewarded.

"The Central Indian Cotton Committee has been set up as a result of the report of the Special Cotton Committee of 1919. Broadly speaking, apart from formal activities, the Committee is a central body charged with the promotion of all measures which will tend to further the improvement of the cotton-growing industry in India,

The *personnel* consists of a fully representative body including the Agricultural Adviser to the Government of India as President, and as members, the Directors of Agriculture and other experts of the Agricultural Department in the cotton-growing provinces, the Director General of Commercial Intelligence, the representatives of the Chambers of Commerce and Commercial Associations, commercial representatives specially nominated by the Local Governments, representatives of the Co-operative Credit Societies, of the cotton growers and of the Indian States. The representative character of the Committee specially qualifies it to advise the Central and Provincial Governments in all matters concerning the industry and affords a common ground on which all sections of the cotton trade, the producers, the traders, the manufacturers and the agricultural and other experts of the Central and Local Governments can meet and discuss difficulties and take joint action to promote objects which are alike the concern of the Government of India, the Local Governments and the Indian States.

"With the passing of the Cotton Cess Act, the Cotton Transport Act, and the active consideration of a Bill for the Regulation of Gins and Presses, the machinery for extending the operations of the Committee is in the process of being perfected. The Committee has already excellent achievements to its credit and great results are to be expected from the schemes of the Committee for the promotion of agricultural and technological research. The Committee can rely on my warm sympathy and on the support of the Member of my Council, Sir Narasimha Sarma, in their operations; and I know that the Ministers-in-Charge of Agriculture in the cotton-growing provinces keep in very close touch with their work. I commend the work of the Committee to the public generally because I am convinced that it is of primary importance to the welfare of India and to the prosperity of her people.

"I will now proceed to perform the inaugural ceremonies."

As His Excellency the Viceroy explained in acknowledging the vote of thanks moved by the Vice-President, the occasion was unique not only because of the great importance to India of the cotton industry, but because of the great interest which every one has in the improvement of the supply of this most important source of clothing.

A booklet describing the Laboratory and its equipment has been published and will be forwarded on application to any readers of the "Agricultural Journal of India" who have not already received a copy. A quotation from this may be permitted as it explains the proposed scheme of work—

"Unlike many other raw materials there are no simple analytical or mechanical tests to which cotton can be subjected to ascertain its value. In consequence cottons are marketed largely on their name and reputation and judged by empirical standards. Hence the only way of really ascertaining the value of a new cotton, at present, is to carry it through all the processes of spinning. The agricultural officer engaged on cotton-breeding operations needs all the assistance which it is possible to give him in determining at the earliest possible stage which of his new types are likely

to prove both acceptable to the spinner and profitable to the grower. The repeated and unanimous statements of agricultural officers that they needed help in this direction led the Committee to decide to provide arrangements for work of this nature under their own direction. The Technological Laboratory which has just been completed will undertake properly controlled spinning tests for Agricultural Departments, will be able to interpret the results and arrange later for the necessary full scale commercial mill trials before new cottons are brought into general cultivation. Since the laboratory equipment is designed to deal with quite small quantities where necessary, it is obvious that such tests should save agricultural officers much time in their work and should render it impossible for an unsuitable type of cotton to be brought into cultivation.

"Essential as the spinning test is in the present state of our knowledge of the cotton fibre, it is by no means ideal as the only test to be applied to new cottons, being not only somewhat expensive but relatively slow. It is highly desirable that an attempt should be made to determine whether it may not be possible ultimately to predict the spinning value of a cotton without having recourse to the spinning test itself, or at any rate to design simpler laboratory methods which will provide sufficient information to enable the plant-breeder to select the best type for further work. Fortunately the additions to our knowledge of the cotton fibre which have resulted from recent investigations in England and America indicate that this should be a particularly fruitful field of work. Once the botanist can be told which of the measurable physical and chemical characters of the cotton hair are of importance in determining spinning quality, he will have a far better chance of determining their inheritance and can guide his operations accordingly. An extensive series of investigations has therefore been planned into the various types of Indian cottons and in every case an attempt will be made to correlate the properties of the cottons with the results of the spinning tests. For these supplementary investigations of a scientific nature the Central Committee decided to erect a Research Laboratory adjacent to the Spinning Laboratory, the provision of which, along with the necessary staff and equipment, renders possible a complete survey of the present standard Indian cottons, as well as the investigation of new types. By repeating these tests on standard cottons from year to year, it will be possible to issue each season a report on the quality of the different cottons, which will no doubt be a useful complement to the information already published regarding the yield. From the various investigations which will be undertaken it is confidently expected that much benefit will be derived in connection with the selection of suitable varieties for growing, and further, that facts concerning different growths will become available which will be of the greatest assistance in the marketing of Indian cottons.

"The small Research Institute which these two laboratories will form will be unique. Two important research institutes have recently been established in England for scientific research in the cotton industry, but their objective is mainly the utilization of the raw materials. In America similar work has been conducted during the

last few years and has had important results not only in the improvement of processes but in the organization of marketing. But the Indian Central Cotton Committee believes its modest institute to be the only one in the world concentrating on the improvement of the raw material and on the growers' needs. It looks to it for far reaching results and for most important assistance in its efforts to help the cotton grower to help himself and to make cotton production more efficient and more profitable."

SIR FRANK GEORGE SLY, K.C.S.I., D.LITT.

AN APPRECIATION.

HIS Excellency Sir Frank Sly who retired in January this year entered the Indian Civil Service in 1887 and was posted to the Central Provinces. After seven years' district work he was promoted to the Government of India as Under Secretary in the Department of Revenue and Agriculture. At the early age of 31 he officiated as Secretary in the same department. At a later date he again served for some time under the Government of India as Inspector General of Agriculture. But the greater part of his service was spent in the Central Provinces where he held several important posts, including that of Commissioner of Settlements, Director of Agriculture, Commissioner, first of Berar and then of Nagpur, Chief Commissioner and finally that of Governor.

During the course of his service he served on several important Commissions and Committees. He was a member of the Royal Commission on the Public Services, Chairman of the Public Works Department Reorganization Committee and of the Champaran Enquiry Committee, and Deputy Chairman of the Franchise Committee.

I had the great pleasure of knowing him intimately and serving under him as Deputy Director of Agriculture in the Central Provinces. To know him and to work with him was to admire his fine qualities of head and heart. He was a great administrator, a good sportsman and a true friend. I still have happy memories of the many pleasant days spent with him on the *jhils* and on the tanks of the Central Provinces when the snipe and duck were in.

His career generally has been fully described in the public press, but to the very important part he played in organizing the work of Agricultural Departments in this country less prominence has been given. He officiated as Inspector General of Agriculture from December 1904 till February 1907. At this time the Imperial and Provincial Departments of Agriculture were in their infancy and the total staff of agricultural experts was very small. As Inspector General of Agriculture one of his main duties was to guide and co-ordinate the experimental and research work of Agricultural Departments throughout India; to publish and criticise the results obtained therefrom, and to suggest new lines of work which might profitably be taken up. In his official capacity he visited every province and gave the Directors of Agriculture thereof most valuable assistance in organizing their departments. His wide experience gained as Inspector General of Agriculture for all India, and as Director of Agriculture in the Central Provinces enabled him to bring to the

SIR FRANK GEORGE SLY, K.C.S.I., D.Litt.

work in agriculture. I went to Pusa in fear and trembling, thinking that the President of this august body would be a very dignified and unapproachable person. When we arrived, however, we were met by the Inspector General himself, and found him then, as I have always found him since, a very human person, ready to welcome and ready to help workers of every kind and to make them at home.

I soon found, however, that he was a man of large vision and of great ideas. I shall never forget that first meeting of the Indian Board of Agriculture. We had, most of us at any rate, been living in a rather small and provincial world. But the Chairman, Sir Frank Sly, quickly lifted us all on to a higher plane and showed us our work as a contribution for the whole of India. It was the day when Pusa was to be an Agricultural College for the whole of India, when crops were considered as being independent of political boundaries, and when India was, in agricultural matters, considered far more as a unified entity than it has since become—for better or worse. Most of the men present were new to agricultural investigation in India or to agricultural propaganda—for the technical staff were mostly new to the country. But serious agricultural investigation was itself new in India, for the existing experimental stations had mostly been conducted very much on routine lines, and agricultural propaganda had hardly been taken seriously. Sly towered so far above most of those present, both in his conceptions of what was possible and in his knowledge at least of how to bring existing information to the notice of cultivators and hence into practice, that he would at once have been a leader even if he had not been in the chair.

During the following year or two, while he still remained as Inspector General of Agriculture, I saw much of Sir Frank Sly. We travelled together in Assam and in Eastern Bengal. He sought my advice in planning the beginnings of agricultural experiments near Dacca, and I had the pleasure of showing him something of tea culture and manufacture, and of sisal hemp cultivation in the Indian tea districts. I have never had a more delightful travelling companion, and in this journey I learnt to admire more than ever his breadth of view and his ability to conceive of a subject as above superficial and temporary considerations.

Sir Frank Sly presided at the second and third meetings of the Board of Agriculture in 1906 and 1907. These were the days of rapid advance. While in 1905 we considered the planning of one Agricultural College for all India, in 1906 it had been decided to establish one in each of the large provinces, and under Sly's guidance a scheme was worked out for these. Men were arriving every few weeks to take up positions in the various Agricultural Departments, and to all these I think he appeared as a great personality.

Shortly after the meeting of the Board of Agriculture at Cawnpore in 1907, Sly ceased to be Inspector General, and again became Director of Agriculture in his own Provinces. I have kept in touch with him, though I have seen little of him since that time. Always, however, when we have met he has shown the same hu-

man character, the same far vision, and the same breadth of view which struck me so much in the olden days.

During the years when he was Inspector General of Agriculture it will be generally recognized that the foundations of the Indian Agricultural Departments, as we now know them, were laid. Whatever they are to-day,—whatever their value, whatever their use,—is built on the foundations and on the plan that he sketched when he was the adviser of the Government of India in matters relating to agriculture. I think it will be generally recognized that the result has been on the whole valuable. Others have built the edifice: he largely assisted in laying the foundation. So, as he leaves India, I cannot resist the invitation to write a note to indicate something of the impression given by Sir Frank Sly in the great days when he was Inspector General of Agriculture.

HAROLD H. MANN.

THE PROBABLE ERROR IN FIELD EXPERIMENTS IN AGRICULTURE.

BY

P. C. MAHALANOBIS, B.Sc., M.A. (Cantab.), I.E.S.,

Professor of Physics, Presidency College, and Meteorologist, Calcutta.

In a recent number (Vol. XVIII, Pt. 5) of the "Agricultural Journal of India" Mr. B. N. Sarkar has discussed the question of estimation and value of "probable errors in variety trials." As the problem is essentially one of a statistical nature, a discussion from the statistical standpoint may prove useful.

From the statistical point of view the factors which affect the yield of paddy (or other crops) may be analysed into several distinct groups.

Consider any particular variety. Even if external conditions are kept absolutely uniform, slight variations in yield will still occur from plant to plant. Such deviations constitute the organic variability of the plant. They will however cancel out if we take the average of a large number of plants and the "mean yield" may be considered to be a stable constant for the variety. The "mean yield" of different varieties will however be different, and the difference in mean yield of two varieties may be conveniently called the "mean organic difference in yield."

Now consider the external factors. Innumerable small fluctuations will occur (from plot to plot or from experiment to experiment) in puddling or levelling the land, manuring, watering, drainage, exposure to rain and sun, etc. These external fluctuations also will however cancel out on averaging for a large number of experiments and may be grouped under "random fluctuations."

"Systematic variations" in the external factors, such as differences in the composition of the soil, in the nature of manure used, in methods of cultivation or in the fertility of land, will, in general, also occur and cannot always be removed. In addition, large accidental errors such as destruction of crops by crabs, rats, birds or other pests, or mistakes in manuring, harvesting or threshing may affect different experiments or different plots in different degrees. Mr. Sarkar says that such accidental errors can be considerably reduced by careful supervision. I shall assume that they are negligible.[1]

There will also remain the random errors of measurements and certain other purely statistical errors. If the number of experiments, *i.e.*, the size of the sample,

[1] These errors are of such a particular nature that a general discussion is theoretically impossible. My assumption, although never strictly true, is therefore unavoidable.

be very large, we can obtain precise information about the value of the "mean yield" and its probability. But in agricultural work the number of experiments is usually small, very often less than 10 or 12, and, as "Student" pointed out some time ago,[1] the probable error found from such small samples is subject to great uncertainty and "judgments reached in this way may become altogether misleading."

Grouping together the different random fluctuations and neglecting large accidental errors we thus have :—

(A) Organic differences in yield.
(B) Systematic variations of the external factors.
(C) Random fluctuations and statistical errors.

Field experiments in agriculture are of two different kinds :—

(1) "Variety trials" in which different varieties are used and, keeping external factors as uniform as possible, the organic differences in yield (A) are determined. The chief point here is to reduce (B) to zero. But this is often impossible in practice; for example, variations in fertility of the land cannot possibly be removed. It then becomes necessary to estimate the effects of (B) and allow for them as accurately as possible.

(2) In another class of experiments, (A) is reduced to zero, *i.e.*, only one single variety is used and the effect of (B) is sought to be determined with accuracy. Experiments with different kinds of soil, or different kinds of manure or different methods of cultivation are typical illustrations.[2]

The problem of estimating (C) remains the same in either class of experiments. It is entirely a statistical question.

In the case of "variety trials" we have the additional problem of estimating (B). This is partly empirical and partly statistical.

I shall first consider (C).

Random Fluctuations and Statistical Errors.

The "mean difference in yield" of any two varieties may be calculated in two slightly different ways. We may first calculate the mean yield of each variety and then find the difference in the mean or we may first calculate the individual difference in yield of adjoining plots and directly find the mean of these differences So far

[1] "The Probable Error of a Mean." *Biometrika*, VI (i), 1908, 1-25.

[2] The generally accepted experimental procedure is apparently as follows. Long narrow strips of experimental plots are prepared and sown with the different varieties in regular recurring series. In the example given by Mr. Sarkar there were 60 strips, each 80′ long and 4′ wide, sown with 6 different varieties. Each variety thus occurred 10 times altogether. Calling the different varieties a, b, c, d, e and f, we may refer to the yields from the different plots in terms of the varieties. Thus the yield from the 1st, 7th, 13th, 19th, 25th, 31st, 37th, 43rd, 49th and 55th plot may be called a (1), a (2), a (3),.... a (9), a (10), from the 2nd, 8th, 14th ..50th and 56th will be b (1), b (2), b (3), .. b (9), b (10) and so on for the other plots.

as the value of the "mean difference" is concerned, the result will obviously be the same, since

Mean of (a)—Mean of (b)=Mean of (a—b).

I quote the figures given by Mr. Sarkar :—

	Kalamdan (*a*)	Indrasal (*b*)	Difference (*a—b*)
	703	670	+33
	705	630	+75
	653	560	+93
	640	615	+25
	700	542	+158
	715	667	+48
	647	702	—55
	848	750	+98
	918	758	+160
	870	830	+40
MEAN .	739·9	672·4	+67·5

The "mean difference" of course is the same whether calculated from 739·9 —672·4 or directly from col. 3.

Apparently however there is some confusion of ideas about the probable error of the difference. The probable error of the difference calculated directly is $\pm$14·1, while the probable error calculated with the help of the formula

$$e\ (a-b)=\sqrt{e^2\ (a)+e^2\ (b)}\ \ldots\ldots\ldots\ldots(1),$$

[where e^2 (a) and e^2 (b) are the squares of the probable errors of mean (a) and mean (b) respectively] is $\pm$28·5. Mr. Sarkar evidently prefers the value obtained by the direct difference method, apparently because it gives a *lower value* in this particular example. This however may not always be the case. The direct difference method can easily give *higher values* of the probable error under other conditions.

The real point is that the direct difference method gives the correct value, while the formula (1) is only valid when the two experiments are entirely independent. The complete expression for the probable error of a mean difference (a—b) is

$$e\ (a-b) = \sqrt{e^2\ (a) + e^2\ (b) - 2\ r\ (a,\ b).\ e\ (a).\ e\ (b)}\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

where r (a, b) is the coefficient of correlation between a and b.

Now in variety trials systematic variation in, say, the fertility of the land is bound to introduce correlation between the different variates and hence, *unless (R) is zero, i.e., unless the external conditions are absolutely uniform and there is no correlation between the variates, the abbreviated formula for calculating probable errors of a difference from the probable error of the "means" will give totally misleading results.*

We conclude therefore that *under usual experimental conditions the probable error of a difference should wherever possible be calculated by the direct difference method.*

I now pass on to the question of the restricted size of samples. The subject has been fully discussed by "Student" in a paper already cited and I need merely quote "Student's" results. He has determined the distribution of a quantity Z, which is obtained by dividing the difference between the mean of small sample and the true mean by the standard deviation of the sample and has also constructed a table for estimating the probability of occurrence of Z.[1] Let us consider the example given above. The mean difference is 67·5 and the standard deviation of the 10 differences is 61·26. Dividing 67·5 by 61·26 we get $Z=1{\cdot}10$.

From "Student's" Table for $n=10$, $p=\cdot 99539$ and $1-p=\cdot 00461$.

The odds are therefore 99539 to 461, or 216 to 1, that Kalamdan gives a greater yield than Indrasal.

Mr. Sarkar finds the value of the probable error of 67·5 to be 14·1. The standard deviation of the mean difference is therefore 20·9 and the mean difference in terms of its standard deviation is 3·238 nearly. From Tables of the Probability Integral, I find that $\frac{1}{2}(1+a)$ is ·999397 and $\frac{1}{2}(1-a)$ is ·000603. The odds are therefore nearly 1700 to 1 in favour of Kalamdan and are much greater than the odds obtained by "Student's" formula.

Of course in the present example it is practically certain that Kalamdan gives a greater yield than Indrasal, and it matters little whether the odds are 1700 to 1 or merely 216 to 1. But the need for caution is obvious and, since "Student" has shown that the probability integral gives too large a value for p when the probability is large, it is extremely important that the correct formula should be used otherwise misleading results may easily be obtained. I conclude that *in estimating the probable error of "mean difference in yield" the table given by "Student" should be used wherever possible.*

I wish to point out that the calculations involved are practically the same, as the standard deviation of the differences must be found in either method. "Student's" Table is also easily available. There is no reason therefore why "Student's" method should not be used more extensively.

The "direct difference" method cannot however be always used. In such cases it then becomes necessary either (i) to determine the correlation between the two variates and use formula (2) or (ii) get rid of the correlation by eliminating the variations in the external factors and then use formula (1).

In either case a further statistical correction will be necessary if the size of the sample is small. As I have already pointed out, this question was first investigated by "Student" in the paper cited above. Two further papers, one by Karl Pearson[2] and another by A. W. Young,[3] have completed "Student's" work in this subject.

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[1] This table has been reproduced as Table XXV, p. 36 of *Tables for Statisticians and Biometricians* (Cambridge University Press).

[2] "On the Distribution of the Standard Deviations of Small Samples." *Biometrika*, Vol. X, p. 522, 1915.

[3] "Standard Deviations of Samples of Two and Three." *Biometrika*, Vol. XI, p. 277, 1916.

Pearson says : " We think it must be concluded that for samples of 50 the usual theory of the probable error of the standard deviation holds satisfactorily, and that to apply it for the case of n=25 would not lead to any error which would be of importance in the majority of statistical problems. On the other hand, if a small sample, n=20 say, of a population be taken, the value of the standard deviation found from it will be usually *less* than the standard deviation of the true population " (p. 528). Tables were constructed by Pearson and Young for making necessary corrections. The correcting factors are given in the following table for easy reference. They are taken from Pearson's and Young's Tables ; but I have put them in a slightly more convenient form for actual use.

TABLE A.

Correcting factors for standard deviations of small samples.

Size of sample	Correcting factor	Size of sample	Correcting factor	Size of sample	Correcting factor
2	Indeterminate	11	1·1056	20	1·0541
3	1·7319	12	1·0955	25	1·0425
4	1·4142	13	1·0871	30	1·0351
5	1·2910	14	1·0801	35	1·0297
6	1·2247	15	1·0742	40	1·0260
7	1·1832	16	1·0691	45	1·0230
8	1·1547	17	1·0646	50	1·0206
9	1·1339	18	1·0607	75	1·0136
10	1·1181	19	1·0572	100	1·0120

To obtain the " corrected " standard deviation we multiply the observed standard deviation of the sample by the appropriate correcting factor taken from the above table. The probable error of the mean will then be obtained from the corrected standard deviation by ordinary methods. The use of the above table will be sufficiently illustrated in later sections.

Construction of the " Normal Fertility Curve."

I shall now consider the problem of estimating systematic variations in the external factors. In certain experiments such systematic variations of external factors are known to exist and cannot be removed. For example, in the illustration given by Mr. Sarkar there is apparently a variation of 40 per cent. in the fertility of the land from one end of the field to the other. It is obviously neces-

sary to make allowances for such variation. Mr. Sarkar has sought to eliminate the effects of such variations by two slightly different methods. In the first he uses one variety as a standard and with its help constructs a "normal fertility curve" for the whole field, while in the second he uses all the different varieties for the same purpose. He then uses the "normal fertility curve" as a standard and considers the difference in yield, *i.e.*, "the departures" from this normal.

The problem will be recognized by statisticians as one of "smoothing." What we want is the "smoothed normal" yield curve of the field as a whole. Each single plot gives a reading, a reading which is made up of the "normal yield" together with a certain deviation imposed upon it by the factors producing variation.

In general there is no reason why any particular variety should give more reliable readings than others. It therefore seems pretty clear that, *unless there is any special reason to the contrary, all the different varieties should be used to determine the "normal fertility curve" of the field.*[1]

The problem of smoothing has received a good deal of attention during the last few years[2] and a large number of formulæ are available for this purpose. It is not however an easy task to choose the most suitable method for any particular case. Mr. Sarkar has used the method of "moving averages"; it is certainly simple, but has no other special merit; it also suffers from the disadvantage that the normal yield for the end-plots cannot be determined by this method.

From the nature of the problem it seems clear that *a very smooth* rather than a very close fit is desirable. My own feeling is that Whittaker's probability method of smoothing would probably give very good results with the present type of material. It possesses several advantages; the total of the variates and their first and second moments (which are often required for statistical purposes) are the same in the smoothed table as in the actual statistics on which the smoothing is based; it has satisfactory logical basis in the mathematical theory of probability; it makes use of the whole material available to graduate each individual value; there is no difficulty near the beginning or end of the plot; and finally the computations are fairly easy and straightforward. The numerical processes are described in detail in Whittaker's book, but I am quoting the necessary formulæ in Appendix I for easy reference.

Taking 6 varieties and all 60 plots I get the following expression for the smoothed or graduated values

$$y=9\ 17{\cdot}54-1{\cdot}34\ 65\ x-0{\cdot}05\ 87\ 88\ x^2$$

[1] This would also serve to eliminate factors of differential fertility. Let us take an extreme case. Consider a field in which the fertility increases for one variety, say (a), and decreases for another variety, say (b), from one end to the other. The fertility curve for (a) and the fertility curve for (b) will then be two single straight lines inclined to one another. Using either the a-curve or the b-curve alone we may get fallacious results, but using both we can get rid of the differential factors.

[2] For an excellent account see "Smoothing" by E. C. Rhodes, *Tracts for Computers*, No. VI (Cambridge University Press, 1921) and also Chapter XI of Whittaker and Robinson's *Calculus of Observations* (Blackie & Co., Ld., 1924).

The graduated values[1] are given in Table I (col. 2) and are plotted as a graph in Diagram 1. Here y gives the yield in *tolas* and x represents the serial number of plots.

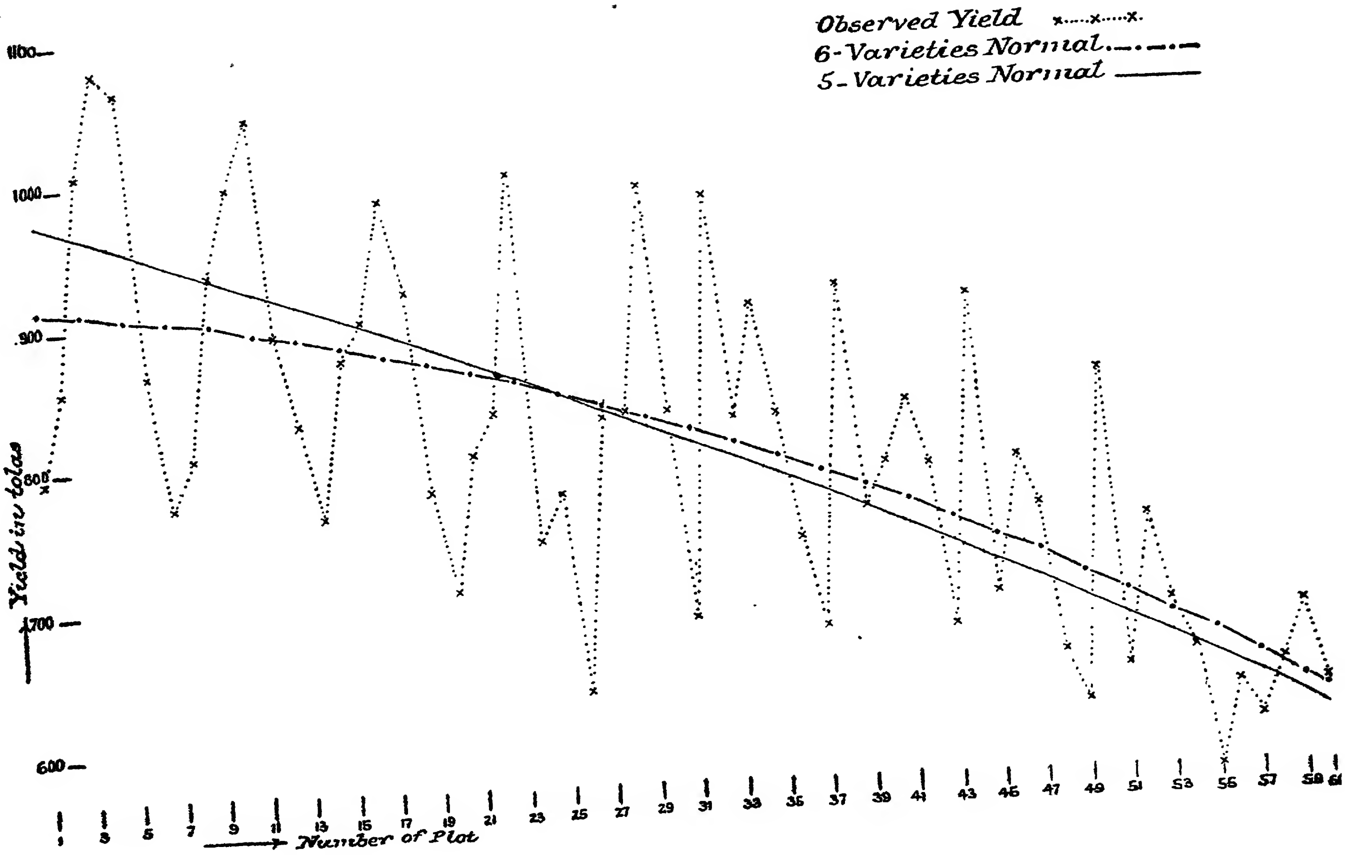
TABLE I.

"Normal yield" (by Whittaker's method).

No. of plot	Normal based on		No. of plot	Normal based on		No. of plot	Normal based on	
	6 varieties	5 varieties		6 varieties	5 varieties		6 varieties	5 varieties
1	916	976	21	863	869	41	761	744
2	915	971	22	859	864	42	755	738
3	913	966	23	855	858	43	749	731
4	911	961	24	851	852	44	742	724
5	909	956	25	846	846	45	735	717
6	907	951	26	842	840	46	728	710
7	905	946	27	837	834	47	722	703
8	903	941	28	833	828	48	715	696
9	901	935	29	828	822	49	707	689
10	898	930	30	823	816	50	700	682
11	895	925	31	818	809	51	693	675
12	893	920	32	813	803	52	685	668
13	890	914	33	808	797	53	677	661
14	887	909	34	802	790	54	670	653
15	884	903	35	797	784	55	662	646
16	881	898	36	791	777	56	654	639
17	877	892	37	785	771	57	646	631
18	874	887	38	780	764	58	637	624
19	870	881	39	774	758	59	629	616
20	867	875	40	768	751	60	621	608

[1] It will be noticed that the "normal yield curve" is nearly linear, showing a very steady decrease of fertility from one end of the field to the other. I have also calculated the correlation between the actual yield and the position of the plot as indicated by its serial number. The coefficient of correlation comes out to be $r = -0{\cdot}67\ 58$. This gives a convenient measure of the variation of fertility. If we assume that all the different varieties are equally affected by this variation, then the correlation between any two varieties will also be 0·67 58 but *positive, i.e.*, the correlation between any two varieties is $r\,(ab) = +0{\cdot}68$ approximately. Mr. Sarkar gives (p. 481) the p. e. of Kalamdan as 21·5 and of Early Indrasal as 19·33. Let us take $e\,(a) = e\,(b) = 20$ approximately. Using the complete expression for the probable error of mean (a—b), we get $\sqrt{20^2+20^2-2\times0{\cdot}68\times20\times20} = \pm 16{\cdot}0$ approximately, which compares very favourably with the value 14·1 found directly by Mr. Sarkar. Evidently the correlation between Kalamdan and Indrasal is higher than +0·68 but is of the same order.

DIAGRAM 1.



Observed Yield
6-Varieties Normal
5-Varieties Normal
1100
1000
900
800
700
600
Yield in tolas
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39
41
43
45
47
49
51
53
55
57
59
61
Number of Plot

Subtracting the normal value (*i.e.*, the graduated value) from the observed value of the yield we get the " departure from normal "[1] and expressing it as a percentage of the normal, we obtain the percentage departure. Tables II and III (which correspond to Mr. Sarkar's Table VII, p. 485) give these percentage departures and the means and other constants.

TABLE II.

Percentage departure from the first normal.

No.	Indrasal	No.	Lochai	No.	Dudhsar	No.	No. 26	No.	No. 51	No.	Kalamdan
1	—13 2	2	— 6 3	3	+10 4	4	+18 6	5	+16·3	6	— 4·4
7	—14 6	8	—10 5	9	+ 3 8	10	+11 1	11	+16 8	12	..
13	— 6·7	14	—14 0	15	—1 0	16	+ 2 2	17	+12 3	18	+ 5 3
19	—10 3	20	—18 1	21	—6 7	22	— 3 0	23	+17 0	24	—12·8
25	— 8 4	26	—24·6	27	—1·1	28	— 0·4	29	+19 3	30	+ 0·9
31	—16 3	32	+20 5	33	+2 1	34	+12 5	35	+ 3 8	36	— 6 7
37	—14 0	38	+17 2	39	—0·8	40	+ 2 6	41	+ 9 2	42	+ 4 1
43	—10·3	44	+22 0	45	—5 4	46	+ 8 5	47	+ 4 6	48	— 9 1
49	—13 0	50	+21 1	51	—7 6	52	+ 8 8	53	+ 0 9	54	— 3 0
55	—14 4	56	— 4 4	57	— 7 1	58	+ 0 5	59	+ 8 1	60	+ 0 6

TABLE III.

Mean percentage departures, etc.

No.	(1) Variety	(2) Mean percentage departure and corrected prob. error	(3) Standard deviation	(4) $Z=M/s$	(5) Odds based on Z
1	No. 51	$+10{\cdot}83 \pm 1{\cdot}46$	6·12	1·77	$>5 \times 10^{3}$
2	No. 26	$+6{\cdot}14 \pm 1{\cdot}54$	6·47	0·95	101·0
3	C. P. Lochai . . .	$+0{\cdot}29 \pm 4{\cdot}09$	17·16	0·02	1·10
4	Dudhsar	$-1{\cdot}34 \pm 1{\cdot}29$	5·42	0·25	3·19
5	Kalamdan . . .	$-2{\cdot}51 \pm 1{\cdot}31$	5·50	0·46	8·76
6	Indrasal	$-12{\cdot}2 \pm 0{\cdot}69$	2·90	4·18	$>10^{4}$

Table III, Col. (2) gives the mean percentage departure with " corrected " probable error (explained below), Col. (3) gives the standard deviation and Col. (4) is " Student's " function $Z=M/s$ (described on p. 99), while Col. (5) gives the odds based on Col. (4) and " Student's " Table.

[1] Mr. Sarkar subtracts the actual value from the normal; his departures are therefore opposite in sign to mine.

The odds are 10,000 to 1 or overwhelmingly against Indrasal and 5,000 to 1 or overwhelmingly in favour of No. 51. The odds are 100 to 1 in favour of No. 26; it is therefore fairly certain that No. 26 gives a better yield than the normal. Dudhsar and C. P. Lochai are more or less average, while Kalamdan is probably slightly inferior.

It will be noticed that C. P. Lochai gives a very high standard deviation 17·16, showing abnormal variations. Mr. Sarkar has noted this; he thinks that it is due to some "accident." I shall come back to this point a little later.

The observed standard deviations given in Col. (3), Table III, are corrected by multiplying them by the factor 1·11 87 (which is the appropriate value for n—10 in Table A above). The corrected probable errors are then obtained by multiplying the "corrected" standard deviations by $\cdot 6745/\sqrt{10}$; they are given in Col. (2), Table III.

We can now proceed to compare any two varieties with the help of the corrected probable errors given in Table III, Col. (2) above. We have presumably got rid of the systematic variations of the external factors, *i.e.*, of the fertility of the land, so that we shall be now justified in using the abbreviated formula $e\,(a-b) = \sqrt{e^2\,(a) + e^2\,(b)}$ for finding the probable error of differences.

Mr. Sarkar has also used a modified form of this formula[1] for constructing his Table VII, but he has not applied the correction for smallness of the size of samples. In the following Table IV, I show the odds calculated by using both the "corrected" and the "uncorrected" standard deviations.

We can also use the percentage departures given in Table II for a direct comparison of any two varieties by the "difference method," using "Student's" Table. I have calculated the odds by this method also and have shown them in Col. (5) of Table IV. The odds are reduced to unity in each case.

TABLE IV.

Varieties compared	Mean percentage difference with prob. error	Odds based on		
		"Uncorrected" prob. error	"Corrected" prob. error	Difference method
(1)	(2)	(3)	(4)	(5)
No. 51 and—				
No. 26 . . .	$+\ 4\cdot69 \pm 2\cdot12$	19·62	13·68	9·73
C. P. Lochai . .	$+10\cdot54 \pm 4\cdot34$	28·76	18·80	8·76
Dudhsar . . .	$+12\cdot17 \pm 1\cdot95$	$>10^6$	$7\cdot7 \times 10^4$	$8\cdot5 \times 10^2$
Kalamdan . . .	$+13\cdot34 \pm 1\cdot96$	$>10^7$	$5\cdot0 \times 10^5$	$3\cdot3 \times 10^3$
Indrasal . . .	$+22\cdot95 \pm 1\cdot61$	$>10^{25}$	$>10^{20}$	$3\cdot0 \times 10^6$

[1] Mr. Sarkar uses the approximation $\sqrt{2}\left\{\frac{e\,(a)+e\,(b)}{2}\right\}$ This introduces a small error in his results. The abbreviated formula (1) is actually simpler in use, as it avoids the multiplication by $\sqrt{2}$ The p. e. of a difference can be written down in a few seconds with the help of Barlow's Table (or any other Table) of squares.

TABLE IV—*concld.*

Varieties compared	Mean percentage difference with prob. error	Odds based on		
		"Uncorrected" prob. error	"Corrected" prob. error	Difference method
(1)	(2)	(3)	(4)	(5)
No. 26 and—				
C. P. Lochai	$+5{\cdot}85 \pm 4{\cdot}37$	5·40	4·43	5·67
Dudhsar	$+7{\cdot}48 \pm 2{\cdot}01$	390	164·7	$1{\cdot}8 \times 10^3$
Kalamdan	$+8{\cdot}65 \pm 2{\cdot}03$	$1{\cdot}6 \times 10^3$	502	100
Indrasal	$+18{\cdot}26 \pm 1{\cdot}69$	$>10^{15}$	$>10^{11}$	$2{\cdot}0 \times 10^4$
C. P. Lochai and—				
Dudhsar	$+1{\cdot}63 \pm 4{\cdot}29$	1·59	1·52	1·52
Kalamdan	$+2{\cdot}80 \pm 4{\cdot}30$	2·20	2·03	5·13
Indrasal	$+12{\cdot}41 \pm 4{\cdot}15$	83	45·10	23·6
Dudhsar and—				
Kalamdan	$+1{\cdot}17 \pm 1{\cdot}84$	2·17	2·00	2·19
Indrasal	$+10{\cdot}78 \pm 1{\cdot}47$	$>10^{10}$	$2{\cdot}8 \times 10^6$	$2{\cdot}04 \times 10^3$
Kalamdan and Indrasal	$+9{\cdot}61 \pm 1{\cdot}48$	$>10^8$	$>10^5$	$2{\cdot}18 \times 10^3$

The "uncorrected" probable errors give too high values for the odds and may easily create a false sense of security. The "difference method" appears to give the lowest odds and hence is probably the safest, but the "corrected" probable errors are not likely to lead to serious mistakes.

The construction of the "normal yield curve" for the whole field is admittedly an empirical process. A very careful examination of the raw material is therefore essential. One way of securing this would be to graduate each variety separately and then compare the results to see if there is any general agreement.

Adopting Whittaker's method I get the following expressions for the graduated values.[1] "y" in each case gives the yield in *tolas* and "x" the serial number of the plot.

No. 51	$y = 11\ 23{\cdot}46 - 6{\cdot}76\ 81\ x - 0{\cdot}01\ 64\ 84\ x^2$
No. 26	$y = 10\ 71{\cdot}95 - 8{\cdot}53\ 72\ x + 0{\cdot}03\ 17\ 61\ x^2$
Dudhsar	$y = 9\ 95{\cdot}94 - 6{\cdot}16\ 87\ x - 0{\cdot}01\ 08\ 38\ x^2$
Kalamdan	$y = 9\ 10{\cdot}73 - 2{\cdot}54\ 70\ x - 0{\cdot}04\ 08\ 25\ x^2$
Indrasal	$y = 8\ 00{\cdot}73 + 0{\cdot}10\ 46\ x - 0{\cdot}08\ 04\ 58\ x^2$
TOTAL	$y = 49\ 02{\cdot}81 - 24{\cdot}0\ 64\ x - 0{\cdot}11\ 66\ 44\ x^2$

[1] I give in an appendix full details of the arithmetical work for one variety, Indrasal.

Dividing by 5, we get

$$\textit{Mean}\ y = 9\ 80{\cdot}56 - 4{\cdot}80\ 13\ x - 0{\cdot}02\ 33\ 29\ x^2$$

The graduated values as well as the departures of the observed values from the graduated values are given in Table V and are plotted in Diagrams 2 and 3. The standard deviations of the departures are also given at the bottom of the columns.

TABLE V.

Departures from normal.

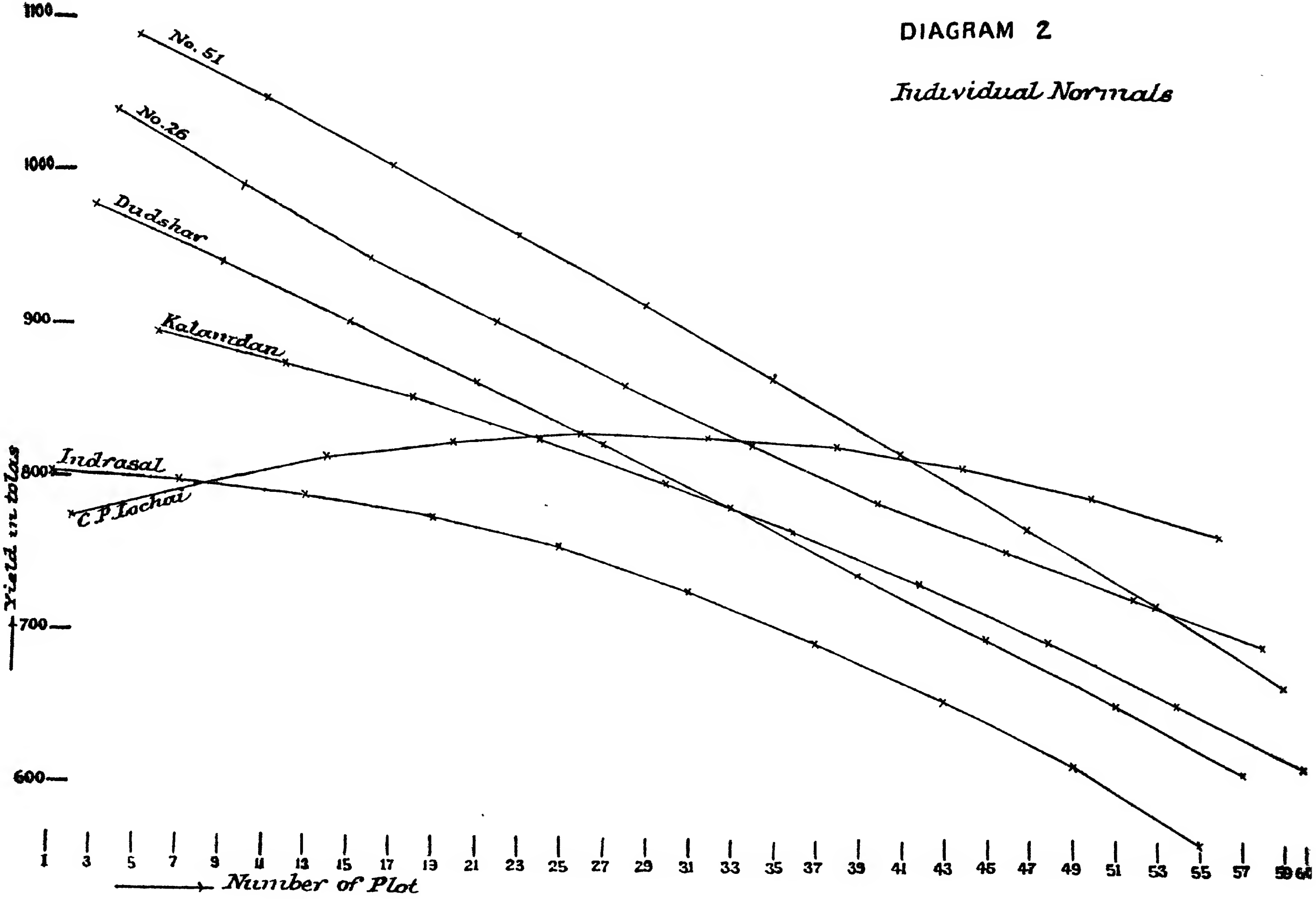
No. 51		No. 26		C. P. Lochai		Dudhsar		Kalamdan		Indrasal	
(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
1089	—32	1038	+42	772	+ 85	977	+31	894	—27	801	—6
1047	— 2	990	+ 8	795	+ 13	940	— 5	874	+19	798	—25
1004	—19	944	—44	813	— 50	901	—26	852	+68	789	+41
959	+41	901	—68	824	—114	862	—57	826	—84	774	+ 6
913	+75	860	—30	829	—194	821	+ 7	798	+32	753	+22
866	—39	822	+80	828	+152	781	+44	766	—28	727	—42
818	+13	786	+ 2	821	+ 93	739	+29	732	+54	694	—19
769	—14	752	+38	808	+ 97	696	— 1	694	—44	656	+16
718	—35	721	+24	789	+ 59	653	—13	654	— 4	613	+ 2
667	+13	692	—52	764	—139	609	— 9	611	+14	563	+ 4
S. D.=31·6		S. D.=48·1		S. D.=107·0		S. D.=28·3		S. D.=44·3		S. D.=23·1	

It will be seen from Diagram 2 that all the different varieties with the one single exception of C. P. Lochai are in satisfactory agreement. The departure curve for C. P. Lochai, as well as its high standard deviation, 107·0, show that it is most probably affected by "accidental" (or sudden and discontinuous) errors. It is obvious that we cannot use it for constructing the field normal. It is too irregular and must be rejected.

We may now combine the 5 concordant varieties and construct the "normal curve." The simplest way of doing this will be to take the arithmetic mean of the 5 component curves. We can obtain the equation for the "normal yield" by simply taking the mean values of the three constants a, b and c. The arithmetic mean has already been given above. The "normal yield" is given in Col. 3 of Table I and is shown as a graph in Diagram 1.

DIAGRAM 2

Individual Normals



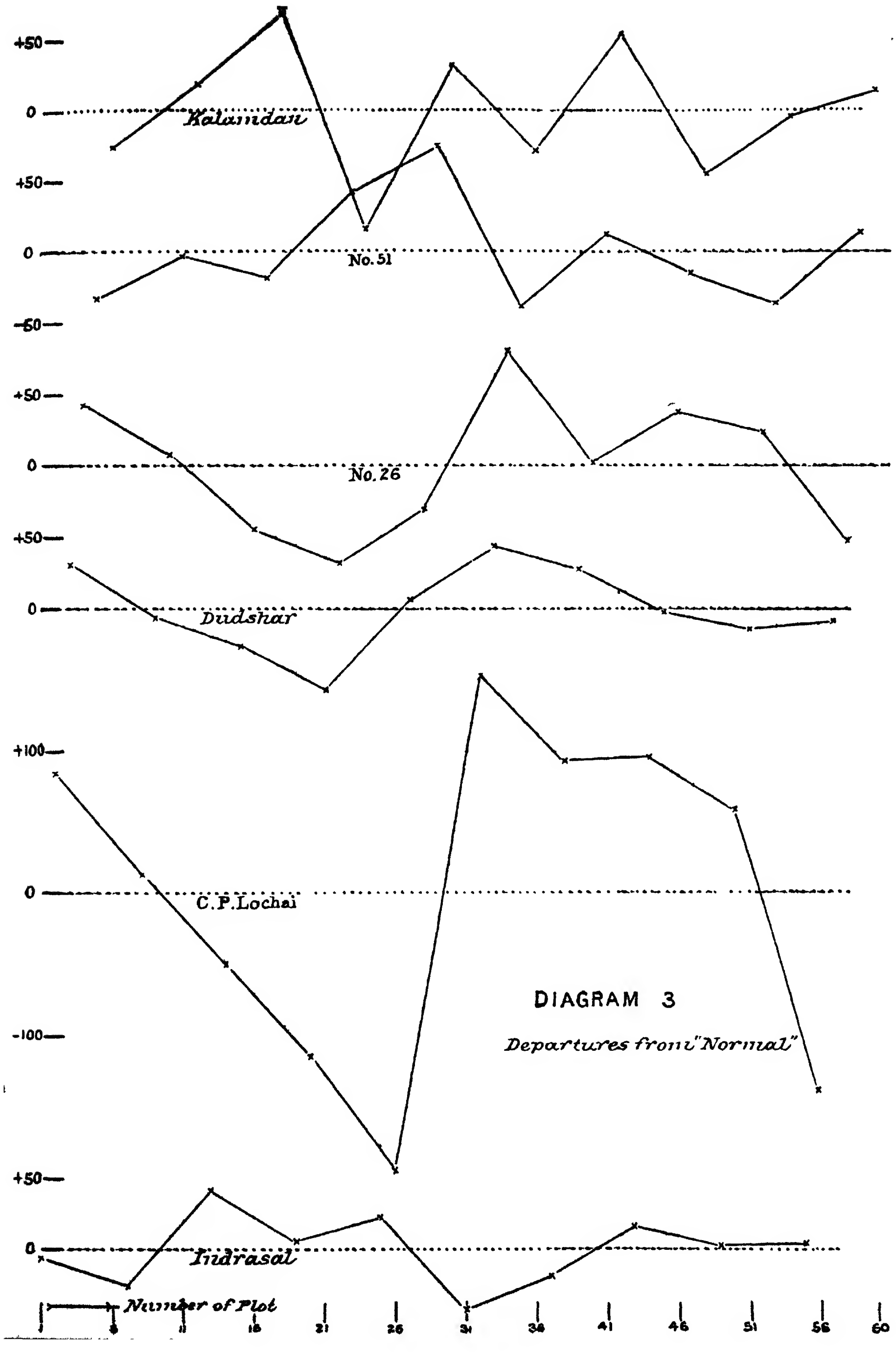


DIAGRAM 3

Departures from "Normal"

Having obtained our "normal" we can now proceed to calculate the percentage departures from normal, mean percentage differences and probability in the same way as described above. Corresponding to Tables II, III and IV we get a new set of Tables VI, VII and VIII which are given below.

TABLE VI.

Percentage departure from the second normal.

No.	No. 51	No.	No. 26	No.	Dudhsar	No.	Kalamdan	No.	Indrasal
5	+10·56	4	+12·38	3	+4·35	6	— 8·83	1	—18·55
11	+12·97	10	+ 7·31	9	..	12	— 2·93	7	—18·18
17	+10·43	16	+ 0·22	15	—3·10	18	+ 3·72	13	— 8·75
23	+16·55	22	— 3·59	21	—7·36	24	— 12·91	19	—11·46
29	+20·20	28	+ 0·24	27	—0·72	30	+ 1·72	25	— 8·39
35	+ 5·48	34	+14·18	33	+3·59	36	— 5·02	31	—15·33
41	+11·69	40	+ 4·93	39	+1·32	42	+ 6·50	37	—12·45
47	+ 7·40	46	+11·27	45	—3 07	48	— 6·61	43	— 8·07
53	+ 3·33	52	+11·53	51	—5·19	54	— 0·46	49	—10·74
59	+10·39	58	+ 2·56	57	—4·91	60	+ 2 80	55	—12·38

TABLE VII.

Mean percentage difference.

Variety	Mean percentage departure with corrected P. E.	Corrected standard deviation
No. 51	+10·90 ± 1·13	5·23
No. 26	+ 6·10 ± 1·39	6·51
Dudhsar	— 1·52 ± 0·88	4·12
Kalamdan	— 2·20 ± 1·39	6·53
Indrasal	—12·43 ± 0·87	4·06

TABLE VIII.

(1)	(2)	Odds based on	
Varieties compared	Percentage difference with corrected P. E.	Corrected P. E.	" Difference " method.
No. 51 and—			
No. 26	$+4 \cdot 80 \pm 1 \cdot 79$	27·45	10·29
Dudhsar	$+12 \cdot 42 \pm 1 \cdot 43$	$>4 \cdot 3 \times 10^5$	$>1 \cdot 0 \times 10^4$
Kalamdan . . .	$+13 \cdot 10 \pm 1 \cdot 79$	$>2 \cdot 6 \times 10^6$	$<3 \cdot 4 \times 10^3$
Indrasal	$+23 \cdot 33 \pm 1 \cdot 42$	Very large	Very large
No. 26 and—			
Dudhsar	$+7 \cdot 62 \pm 1 \cdot 64$	$>1 \cdot 1 \times 10^3$	$>1 \cdot 9 \times 10^3$
Kalamdan . . .	$+8 \cdot 30 \pm 1 \cdot 97$	456·5	91·76
Indrasal	$+18 \cdot 53 \pm 1 \cdot 64$	Very large	$>2 \cdot 4 \times 10^4$
Dudhsar and—			
Kalamdan . . .	$+0 \cdot 68 \pm 1 \cdot 65$	1·57	1·57
Indrasal	$+10 \cdot 91 \pm 1 \cdot 23$	$>7 \cdot 7 \times 10^8$	$>2 \cdot 7 \times 10^3$
Kalamdan and Indrasal .	$+10 \cdot 23 \pm 1 \cdot 64$	$>7 \cdot 8 \times 10^4$	$>3 \cdot 8 \times 10^3$

We see again that the " difference method " gives the lowest odds. It should be remembered however that the plots compared are in certain cases widely separated, *e.g.*, Indrasal and Kalamdan, where the first plot of Kalamdan is separated from first plot of Indrasal by 4 intervening plots but is actually contiguous to the *second* plot of Indrasal.

The " Sub-plot " Method.

In order that the present method may give reliable results it is obviously necessary that the " normal yield curve " should be a reasonable description of the actual variation of fertility of the field. In fact the reliability of the present method depends entirely on the probability that the normal yield curve is a true description of the actual situation. In order to appreciate the real probability of the results obtained by the present method it is therefore necessary to determine the probability of the normal yield curve.

Now the normal yield curve is built up from the separate individual yield curves which in their turn are obtained from the values of the yield for each individual plot. The probability of the normal yield curve thus ultimately rests on the probability of the yield for each individual plot. It is therefore essential that we should have some basis on which we can determine the probable error of the yield for single plots. This point is of vital importance, but unfortunately in the procedure usually

adopted in agricultural experiments absolutely no way is left for determining the probable error of the yield of single plots.

The only possible basis on which this can be done is to divide each plot into a number of sub-plots and secure the yield from each separate sub-plot. The scheme can be diagrammatically represented as follows :—

a (11)	b (11)	c (11)	..	..	..	a (21)	b (21)	..	..
a (12)	b (12)	c (12)	..	..	..	a (22)	b (22)	..	..
a (13)	b (13)	c (13)	..	..	..	a (23)	b (23)	..	..
a (14)	b (14)	c (14)	..	..	..	a (24)	b (24)	..	..
a (15)	b (15)	c (15)	..	..	..	a (25)	b (25)	..	..
a (1·)	b (1·)	c (1·)	..	..	..	a (2·)	b (2·)	..	..

As at present arranged the yield for the whole plot a (1) is determined integrally. In the method proposed the plot a will be divided into a number of sub-plots a (11), a (12), a (13), a (14) .. .. etc., and the yield for each sub-plot will be determined separately. The total yield for a (1) will then be obtained by adding the yield for all the sub-plots.

The essential point, however, is that this method will enable us to determine the probable error of a (1), a (2), a (3) .. .. . The probability of the graduated yield-curves for a, b, c (*i.e.*, for all the different varieties) can then be found and finally the probability of the normal yield curve itself.

The additional labour involved in the purely agricultural portion of the work is negligible. The only thing necessary will be to mark out the sub-plots a (11), a (12), a (13) .. b (11), b (12), b (13) .. .. etc.

Harvesting, threshing and weighing will however have to be carried out individually for each of the sub-plots a (11), a (12) .. .. .. b (11), b (12) .. .. etc., and will entail a much larger number of measurements. But the additional labour involved will probably be fully justified in view of the additional accuracy and the greater significance of the results which may be secured by this method.

I conclude therefore that *in order to obtain reliable results it is absolutely essential to adopt the above " sub-plot " (or " chess-board pattern ") method of laying out the experimental plots.*[1]

Summary of Conclusions.

It may be useful to indicate briefly the chief conclusions of my discussion.

(*a*) It is desirable to adopt, wherever possible, the " direct difference " method for finding the probable error of a mean difference and to use " Student's " Table for finding the probability.

(*b*) Wherever external variations are known to occur, it is desirable to eliminate their effect by considering departures from the " normal."

[1] I have indicated briefly in Appendix III suitable statistical formulæ which may be conveniently used in connection with the "sub-plot" method.

(c) In constructing the "normal," as many varieties as possible should be used ; and

(d) preferably, the results for each variety should be graduated separately and then combined together for constructing the "normal," after elimination of irregular varieties.

(e) In finding the probable error from small samples it is desirable to "correct" the observed standard deviations by multiplying them by suitable correcting factors. (A table of correcting factors has been given above.)

(f) Statistically speaking, it is absolutely essential to adopt a "sub-plot" method of laying out the field in order to determine the reliability of the "normal" used.

I note with interest that Mr. Sarkar proposes to test different statistical methods in connection with the results of further trials. May I suggest that in doing so he will keep in view the results offered above. Personally I shall be only too glad to give such statistical help as may lay in my power.

I am grateful to Dr. C. W. B. Normand, M.A., D.Sc., Officiating Director-General of Observatories, for drawing my attention to Mr. Sarkar's paper. I am also much indebted to my Assistant Babu Devendranath Chakravarti for arithmetical aid.

Appendix 1.

Whittaker's method of smoothing.

Let a (1), a (2), a (3), ... a (n) be the successive yields. We then find the following fundamental constants by straightforward summation.

$$M_0 = a\,(1) + a\,(2) + a\,(3) + \quad \cdots \quad + a\,(n)$$

$$M = 1.\,a\,(1) + 2.\,a\,(2) + \quad \cdots \quad + n.\,a\,(n)$$

$$M = 1^2.\,a\,(1) + 2^2.\,a\,(2) + \quad \cdots \quad + n^2.\,a\,(n)$$

Arranging the work in tabular form :—

	Yield		
(1)	(2)	(3)	(4)
Number of Indrasal plot = n	= a (n)	n. a (n)	n^2. a (n)
1	7 95	7 95	7 95
2	7 73	15 46	30 92
3	8 30	24 90	74 70
4	7 80	31 20	1 24 80
5	7 75	38 75	1 93 75
6	6 85	41 10	2 46 60
7	6 75	47 25	3 30 75
8	6 72	53 76	4 30 08
9	6 15	55 35	4 98 15
10	5 67	56 70	5 67 00
Sum	71 67	3 72 42	25 04 70

We get $M_0=71\ 67$, $M_1=3\ 72\ 42$, $M_2=25\ 04\ 70$.

From these we next obtain the following constants (remembering $n=10$).

$$p=\frac{M_0}{n}=\frac{7167}{10}=716{\cdot}7$$

$$q=\frac{2\,M_1}{n\,(n+1)}=\frac{2\times 372\ 42}{10\times 11}=677{\cdot}09$$

$$r=\frac{6\,M_2}{n\,(n+1)}=\frac{6\times 25\ 04\ 70}{10\times 11}=1\ 36\ 60{\cdot}18\ 18$$

$$s=\frac{6\,(q-p)}{n-1}=\frac{6\,(677{\cdot}09-716{\cdot}7)}{9}=-26{\cdot}40\ 60\ 61$$

$$t=\frac{2[r-(2n+1)\,p]}{n-1}=\frac{2\,[13600{\cdot}1818-21\times 716{\cdot}7]}{9}=-309{\cdot}00\ 40\ 40$$

From these we get finally—

$$c=\frac{15\,[t-(n+1)\,s]}{(n+2)\,(n-2)}=\frac{15\,[-309{\cdot}00\ 40\ 40+11\times 26{\cdot}40\ 60\ 61]}{12\times 8}=-2{\cdot}89\ 64\ 63$$

$$b=s-(n+1)\,c=-26{\cdot}40\ 60\ 61+11\times 2{\cdot}89\ 64\ 63=+5{\cdot}45\ 50\ 32$$

and $a=q-\frac{2\,n+1}{3}\,.\,b-\frac{n\,(n+1)}{2}\,.\,c=677{\cdot}09-7\times 5{\cdot}45\ 50\ 32+55\times 2{\cdot}89\ 69\ 63+798{\cdot}21.$

The graduated values will then be given by :—

$$y=a+bZ+cZ^2=798{\cdot}21+5{\cdot}45\ 50.\ Z-2{\cdot}89\ 64\ 63.\ Z^2$$

where Z refers to the number of Indrasal plots :—1, 2, 3, ... 10.

But these correspond to the serial number x :—1, 7, 13, ... 55. Evidently $Z=\frac{x+5}{6}$. Substituting this value in the above equation,

$$y=7\ 98{\cdot}21+5{\cdot}46\ 50\ \frac{(x+5)}{6}-2{\cdot}89\ 64\ 63\ \frac{(x+5)^2}{6^2}$$

or $y=8\ 00{\cdot}73+0{\cdot}10\ 46\ x\ -0{\cdot}08\ 04\ 58\ x^2$

the value quoted above.

As I have already pointed out, we want a very smooth fit. I therefore stop here and do not try to improve the fit by the method described by Whittaker.

Appendix II.

The mean difference for graduated values can be obtained very easily with the help of simple algebraic expressions

Let $y_1=a_1+b_1\ x+c_1\ x^2$ and $y_2=a_2+b_2\ x+c_2\ x^2$ be any two graduated yield-curves where "y" gives the yield and "x" the serial number of the plot. Then $Z=y_1-y_2=A+B\ x+C\ x^2$ where $A=a_1-a_2$, $B=b_1-b_2$ and $C=c_1-c$.

It can be easily shown that the mean value of the difference

$$Z=A+B.\ \frac{1}{n}\ S\ (x)+C.\ \frac{1}{n}.\ S\ (x^2)$$

and the square of the standard deviation of Z,

$$s^2\ (z)=\left[\frac{1}{n}.\ S\ (x^2)-\left\{\frac{1}{n}.\ S\,(x)\right\}^2\right]\ B^2$$
$$+\left[\frac{1}{n}\,S\ (x^3)-\frac{1}{n^2}\ S\ (x)\ S\ (x^2)\right]\ BC$$
$$+\left[\frac{1}{n}\ S\ (x^4)-\left\{\frac{1}{n}\ S\ (x^2)\right\}^2\right]\ C^2$$

where S denotes a summation for the different values of n.

Now in the present type of problem x will usually take the form a+(n—1) d where, "a" = general serial number of the first plot, "n" = the number of plots sown with each variety and "d" = number of different varieties. For example, in the illustration given by Mr. Sarkar n=10 and d=6. For Indrasal a= 1, and we get 1, 7, 13 .. .. 55 for successive values of x.

Thus putting x=a+(n—1) d, we get

$$\frac{1}{n}\ S\ (x^2)-\ \left\{\frac{1}{n}\ S\ (x)\right\}^2=\frac{n^2-1}{12}\,.d^2$$

$$\frac{1}{n}\,S\,(x^3)-\ \frac{1}{n^2}\ S\,(x).\ S\,(x^2)=\ \frac{n^2-1}{12}\ .d^2\left\{2a+(n-1)\ d\right\}$$

$$\frac{1}{n}\ S\ (x^4)-\left\{\frac{1}{n}\ S\ (x^2)\right\}^2=\frac{n^2-1}{3}\ .\ d^2\left\{a^2+(n-1)\ a.\ d+\frac{16n^2-30n+1}{60}\right\}$$

from which Z and s (z) can be easily found.

APPENDIX III.

Goodness of fit of the "normal curve."

We may apply the X^2 test for "goodness of fit" devised by Karl Pearson. Let a (1), a (2), a (3) .. .. , in general, a (n) be the yield of the nth a—plot, let a(O)=mean yield of all a. plots taken together and s^2 (a)=the square of the standard deviation of all a. plots irrespective of the position in the field. Let p be the number of sub-plots into which *each* plot is divided and let n=total number of a. plots altogether.

Then the correlation ratio η (of yield on position of the plot) is defined by the equation

$$\eta^2=\frac{p}{n}.\ S\ \left\{\frac{(n)-a\,(o)}{s^2\,(a)}\right\}^2$$

where S denotes a summation for all n values of a.

Let a^1 (n) be the graduated value corresponding to observed value a (n).

Karl Pearson has suggested the following value* for X^2.—

$$X^2=p.\ \frac{S\left\{a\ (n)-a^1\ (n)\ \right\}^2}{(1-\eta^2).\ s^2\ (a)}$$

The value of X^2 can be easily calculated with the help of the above two formulæ.

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* "On the application of 'Goodness of Fit' Tables to test Regression Curves and Theoretical Curves used to describe Observational or Experimental Data." *Biometrika*, XI (1915-1917). 239-261.

Tables are available for finding the probability of the fit from observed values of X^2, the quantity defined above.*

It should be remembered that here the total number of independent variables is n in the present case and hence the probability Tables for X^2 should be looked up under $n^1 = n+1$.

Having obtained the probability for each separate curve we can assign suitable statistical weights to the different curves in constructing the normal. The probability of the normal can then be found either from the constants of the component curves or directly from the correlation ratio of the yield on position in the field for all plots taken together In the absence of actual material I am unable to give a numerical illustration.

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* *Biometrika*, I (1903), 155-163, reprinted as Table XII, p. 26, *Tables for Statisticians and Biometricians.*

FURNACES FOR THE MANUFACTURE OF JAGGERY OR GUR

BY

W. SMITH-ROLLO, A.M.I.E. (India),

Agricultural Engineer to Government, Burma.

In Burma, the area under sugarcane has more than doubled itself within the last 10 years and, as a result of this, the enormous amount of timber consumed in the furnaces in the province has forced the Forest Department to restrict the supply of fuel.

The cane-grower here ordinarily uses fuel 5–8 inches in diameter and 6–9 feet long and costing from Rs. 1-8 to Rs. 3 per cartload of approximately 1,000 lb.

One of the greatest problems, therefore, in the sugarcane districts is the supply of fuel, and for the last 18 months the author and his staff have devoted much time to the designing of a furnace which would be able to burn the megass or crushed cane and at the same time evaporate the juice without the addition of any wood fuel.

In the experiments hereafter related none of the leaves or trash was burnt but megass only, thus releasing a certain quantity of valuable manure which can be ploughed into the land, although it is usually set on fire before ploughing.

This year in the Yamethin District near Pyinmana which is the centre of the most important cane-growing district in Burma, two experimental furnaces were erected and the object aimed at was to produce a furnace which would not differ too greatly from the Burmese furnaces to be popular with the growers and at the same time which would effect a saving of fuel and time.

1. The Ordinary Burmese Furnace.

This consists of a pit 6 feet long by 3 feet broad by 3 feet deep, and at one end of this a tunnel about 18–24 inches in diameter is started for the fire-box and continued for a distance of about 20 feet, holes being cut in the roof for the placing of pans as shown in Fig. 1. These pans are usually about 45 inches in diameter and 15 inches deep at the centre and hold 32 gallons or 8 kerosine tins of juice.

No chimney is usually built but if so it is never more than 2 or 3 feet high, and logs about 6 inches in diameter and 6 feet long are always burnt.

This furnace is also to be seen partly excavated and partly built with bricks.

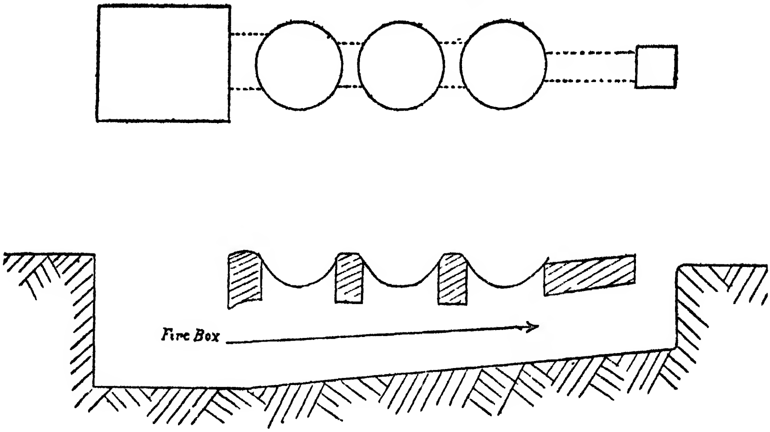


Fig. 1. Ordinary Burmese furnace (without fire-bars) Scale, 1/6 inch = 1 foot roughly.

This furnace is most inefficient.

(*a*) As no fire-bars are provided the supply of air is not sufficient for complete combustion, and the fire-box gets choked up with partly consumed fuel and requires cleaning out very often.

(*b*) No chimney is provided, therefore draught is small with the result that the fire is not drawn through the flue properly.

(*c*) The megass is not usually burnt at all in these furnaces but thrown away. The figures regarding fuel consumption, etc., of this furnace are as shown under.

TABLE I.

Type of furnace	Variety of cane	No. of		Weight of				Outturn of megass		No. of hours boiled	Fuel used	
		Canes	Tins of juice	Cane	Juice	Jaggery	Calculated available megass	Green	Fit for burning		Megass	Timber
				lb.	lb.	lb.	lb.	lb.	lb.			lb.
Burmese Ordinary	Pyinmana	3,750	166	11,878	6,958	666	4,920	3,567	2,676	16 hrs	nil	6,000

2. THE IMPROVED LOCAL FURNACE.

This is very similar to the local furnace except that—

(*a*) It has more brickwork to raise it, thus allowing for an ashpit.

(*b*) Fire-bars are fitted, usually old cart axles.

Ordinary Burmese Dugout Furnace.

Improved Burmese Furnace with fire-bars.

(*c*) Fire-doors are fitted.
(*d*) Chimney of 6–15 feet is added.

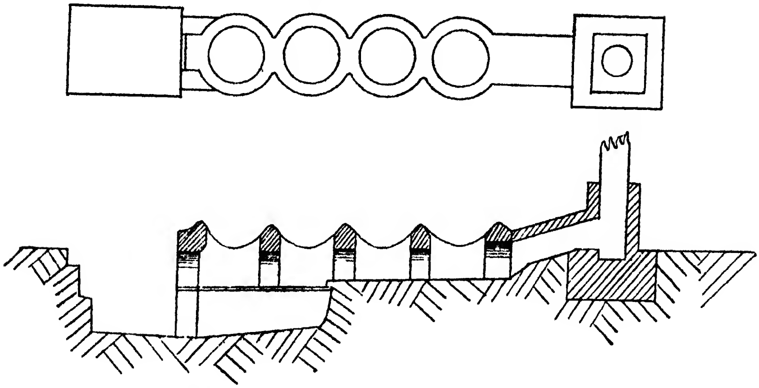


Fig. 2. Improved Burmese furnace with fire-bars.
Scale, $\frac{1}{10}$ inch = 1 foot roughly.

The above furnace is much more efficient but has the following faults—

(*a*) Fire-box area about 16 sq. feet.
(*b*) Large timber has still to be burnt in addition to burning all available megass.
(*c*) A great amount of heat is lost owing to the flues being straight through and very large. The draught from the chimney draws most of the fire past the pans and too much heat escapes up the chimney.
(*d*) The fireman finds it very difficult to stay near the fire-door on account of the great heat thrown out.
(*e*) The combustion is not complete owing to the flues, fire-box, etc., not being correctly proportioned.
(*f*) Large quantities of ash are formed.
(*g*) Fire is not easily shut down at night when boiling is finished; therefore, large quantities of water have to be carried and the pans filled up to prevent cracking. The figures for the furnace are as follows:—

Type of furnace	Variety of cane	No. of		Weight of				Outturn of megass		No. of hours boiled	Fuel used	
		Canes	Tins of juice	Cane	Juice	Jaggery	Calculated available megass	Green or wet	Fit for burning		Megass	Wood
				lb.	lb.	lb.	lb.	lb.	lb.	hrs min.	lb	lb.
Improved Burmese	Pyinmana		235	16,314	9,880	1,444	7,434	4,390	3,303	16 12	2,307	2,362
			124	8,927	5,208	637	3,719	2,697	2,063	14 54	nil	3,545
			174·5	12,620·5	7,544	1,040·5	5,576·5	3,543	2,683	15 33	1,250	2,953

It will be seen that this furnace effects a saving of approximately four cartloads of timber per day.

3. IMPROVED FURNACE, STRAIGHT TYPE, KNOWN AS "BURMA FURNACE."

This is a modification of the local improved furnace, but with flues and fire-box, etc., more carefully proportioned and fitted with baffle plates to direct the hot gases against pan bottoms.

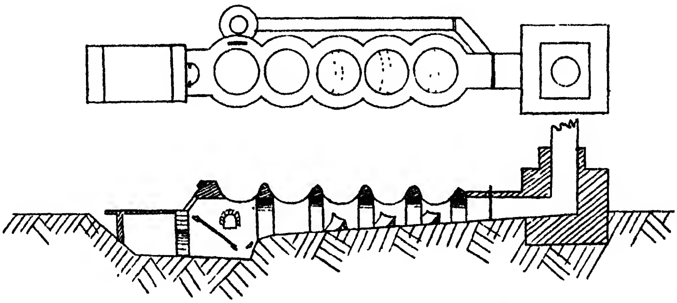


FIG. 3. Improved megass burning furnace designed by the Agricultural Department.
Scale, $\frac{1}{12}$ inch = 1 foot roughly.

The fire-box in this furnace is designed after the fashion of megass-burning furnaces in use in Java and America. The fire-bars are similar to those used in paddy husk furnaces and are 3 feet long, 6 inches wide and $\frac{3}{4}$ inch thick with a strengthening rib running down the centre of each. The perforation in these fire-bars is shown below.

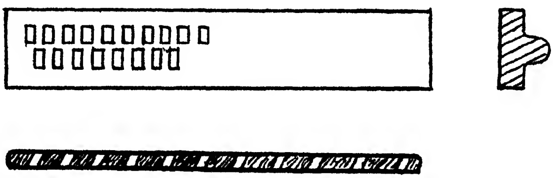
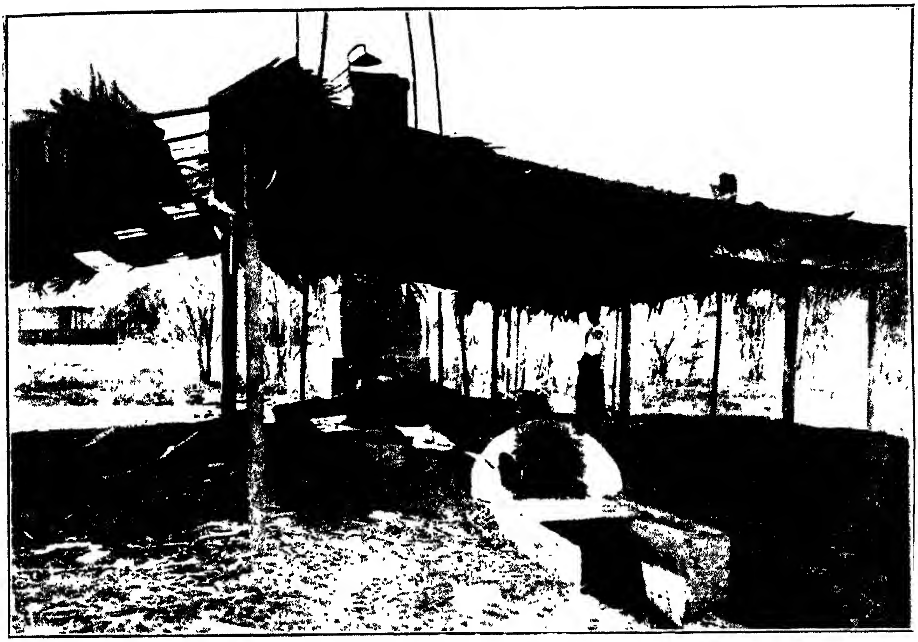
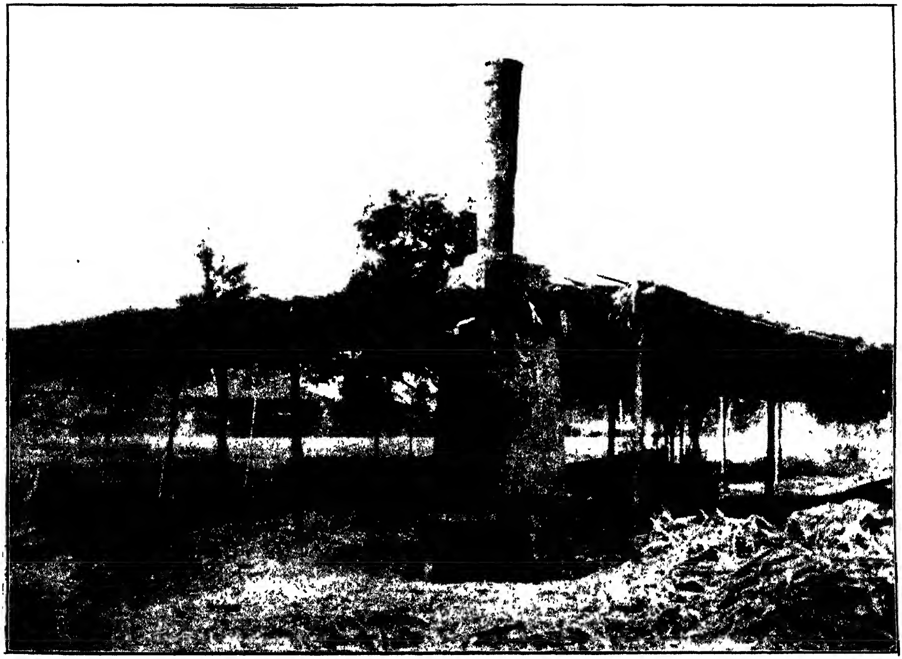


FIG. 4.

Five of these are used in the fire-box and four are placed at an angle of 45° to the horizontal, the bottom of the bars being about 9-10 inches from the ground to allow clearing ashes. The fifth bar is placed across the fire-box at the bottom of the bars as shown. The actual fire-box area is thus only 6 sq. feet.

As it is not possible in such small furnaces to feed megass from overhead, as there is not sufficient drop to allow it to fall on the bars, the feeding door is placed


Improved Departmental Long Furnace.


Return Type Furnace, General View.

at right angles to the slope of the bars and a platform is placed here on which the megass is laid and when required it is easily pushed into the furnace with a short pronged fork.

Specially shaped baffle plates are fitted under each pan to direct the hot gases against the pan bottoms, and the ashpit opening is completely closed with an iron plate which has adjustable air inlets as shown in Fig 5.

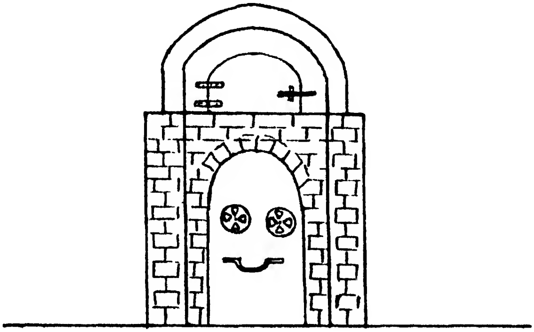


FIG. 5.

This is to shut out all cold air and only allow in sufficient air as is required to complete the combustion. Before the flue enters the chimney there is also a damper fitted to enable the draught to be regulated and at the same time to damp down the fire at night, so that practically only the pan directly over the fire-box has to be filled with water.

This furnace in practice was found to require 1–1½ cartloads of timber per day in addition to megass, but there is a saving of 4½–5 carts a day over the Burmese type of furnace.

For finishing the *jaggery* a small pan is set at the side of the fire-box with a damper at the fire-box and another where the auxiliary flue enters the main flue. The second damper is to shut out air from spoiling the draught when the finishing pan is lifted off.

The two dampers work simultaneously as they are interconnected by an overhead wire running over small pulleys.

Two examples of the superiority of this furnace over the improved Burma furnaces may be taken.

(1) Maung Tun E, near Lewe, had one of these departmental furnaces erected this year, using the same number of pans as he used with his Burmese furnace. The result is that his crusher, which previously gave ample juice to keep his furnace going continuously, is now no longer able to do so. His boilers, therefore, fill up all the pans, evaporate the juice, then go to sleep for about 2 hours until more juice is ready. In this case the departmental furnace would be able to keep two crushers going, *i.e.*, about 140 gallons juice per hour, and this without an ashpit air regulator.

(2) One U E Baw, Thugyi of Tedaung village, who fed his megass very carefully was able to boil without any timber except a little used to kindle his fire.

The figures for this long type of furnace are as shown under.

Type of furnace	Variety of cane	No. of		Weight of				Actual megass		No. of hours boiled	Fuel used		Remarks
		Canes	Tins of juice	Cane	Juice	Jaggery	Calculated available megass	Green or wet	Dry or fit for burning		Megass	Timber	
				lb.	lb	lb.	lb.	lb.	lb.	hrs.	lb.		
Long Improved.	Pyinmana .	615	21	1,388	683	129	705	494	418	2	485		Extra megass was available, so this was used in place of timber.
	,, .	3,600	160	10,250	5,280	1,053	4,970	2,512	1,826	9	1,900	nil	
	Pyinmana mixed with Thaton.	3,560	160	10,236	5,280	920	4,956	3,868	2,460	10	2,662		

4. Improved Furnace, Return Type.

The most efficient type of furnace yet designed, however, is as shown below. This is of the return type and is called by the Burmans " Lay Bwint Saing," meaning " cluster of four flowers."

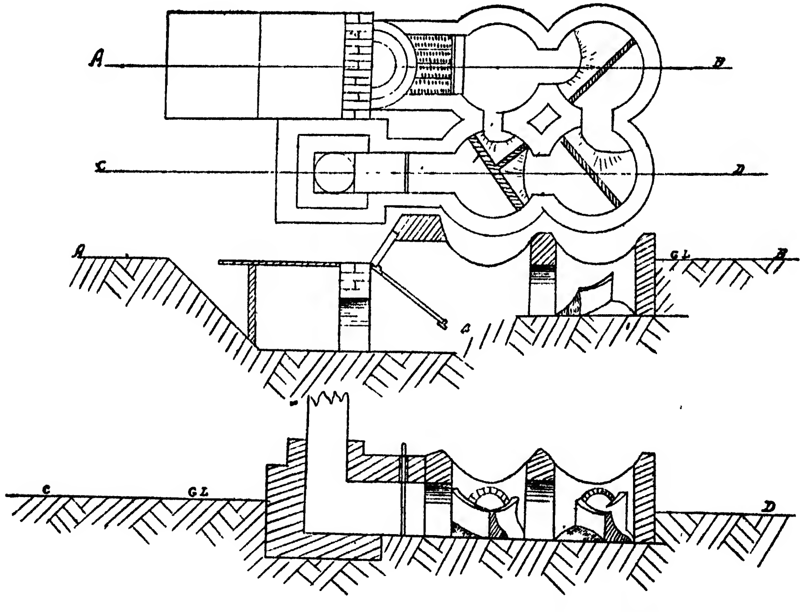
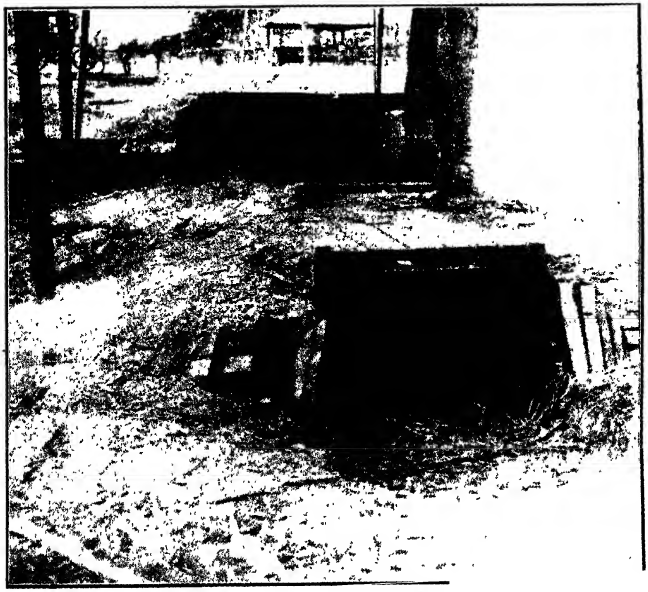


Fig. 6. Return type furnace for megass burning designed by the Agricultural Department
Scale, $\frac{1}{8}$ inch = 1 foot roughly.

Return Type Furnace.



Fire-box of Return Type Furnace.

This furnace is as shown above and has a grate area of 6 sq. feet. The fire-box is similar to that in the long furnace and there is also a damper in the flue between the last pan and chimney.

There is also a small bypass flue from the fire-box to the last pan to enable all the pans to be kept boiling. The finishing furnace is a small additional one as shown in Fig. 7 which also burns megass.

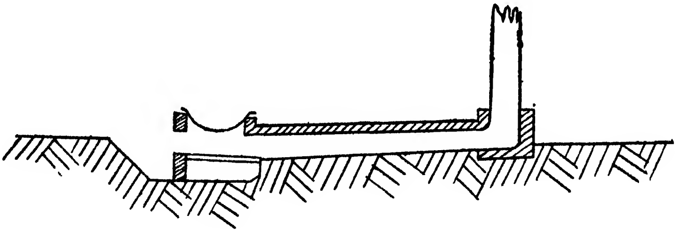


FIG. 7.

In one experiment with this furnace there was left over an excess of 135 lb. megass per hour after evaporating the juice obtained, but this was due to the cane used having a fairly large fibre content and being Java and Toungoo cane the megass of which is harder.

In every case, however, by careful stoking the amount of megass obtained from crushing the cane exceeded the amount used for firing the furnace and the results obtained were as follows:

Type of furnace	Variety of cane	No. of		Weight of				Actual megass		No. of hours boiled	Fuel used		Remarks
		Canes	Tins of juice	Cane	Juice	Jaggery	Calculated available megass	Green or wet	Dry or fit for burning		Megass	Timber	
				lb.	lb.	lb.	lb.	lb.	lb.	hr. m	lb.		
Short Improved	Pyinmana	879	30	1,983	975	185	1,008	705	596	2	325	nil	
		2,230	70½	4,810	2,524·5	564	2,285	1,823	1,593	7 25	1,530		
		2,361	66	4,340	2,178	437	2,162	1,680	1,289	8	1,278		

Next cane season further experiments will be carried out with a view to further improvements in the furnace already designed.

The illustrations accompanying this article will give one a good idea of the general appearance of the different furnaces. (Plates VI—VIII.)

SELECTED ARTICLES

LIVESTOCK IMPROVEMENT IN ENGLAND AND WALES IN 1923-24.*

THE reasons for the introduction of the Livestock Improvement Scheme in 1914, its object and the lines on which it operates have been set out so fully and often in the Journal and elsewhere as to need but brief recapitulation here.

At the outset it was realized that the funds available for the purposes of the scheme in England and Wales precluded any ambitious attempt at the direct provision by the Government of high-class sires required for use in the grading up of inferior farm stock, even had this been practicable or advisable.

The scheme was, therefore, framed more as an educational measure with the object of showing, by practical demonstration throughout the country, the importance and value of care in the selection and use of good pedigree sires and the direct gain resulting from the application of knowledge obtained from taking milk records and managing dairy herds in a more systematic and economic manner.

For these purposes annual grants are made to bull, boar and heavy horse societies which undertake the provision of approved pure-bred sires for the use of their members and to milk recording societies operating under the scheme.

That the objects aimed at are being achieved is indicated by the annual increase in the number of sires subsidised and the growing interest in and development of the milk recording movement as shown in the tables herewith.

Apart from the direct benefit accruing to the agriculture of the country by reason of the grading up of inferior stock through the instrumentality of the scheme—the focussing of attention on livestock improvement and the association of the Ministry's Livestock Officers with farmers and small holders in their several districts has had some influence, though indirect, in stimulating interest in breeding, in increasing the number of breeders and users of pure-bred cattle and pigs, and in creating a bigger demand for suitable sires amongst people not directly concerned with the scheme.

Bulls. The total number of bulls actually located for service during the year ended 31st March, 1924 (*i.e.*, continued from previous years with renewed grants or provided for fresh districts during the year), was 978, an increase of 31 on the preceding year.

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* Reprinted from *Jour Min. Agri.*, XXXI, No. 6.

Bull scheme.

(Showing the number of bulls subsidised during the past 10 years.)

Year	Societies	Individuals	Total No. of bulls
1st April to 31st March—			
1914-15*	369	43	497
1915-16	489	28	633
1916-17	543	15	659
1917-18	578	14	710
1918-19	604	7	721
1919-20	568	6	675
1920-21	561	6	668
1921-22	726	3	847
1922-23	831	1	947
1923-24	840	1	978

* Including the period 1st February, 1914—31st March, 1914

This increase, though not large, is satisfactory in view of the restrictions on movement of stock in force during a large portion of the year owing to the prevalence of foot-and-mouth disease. In districts not so hampered the Ministry's Livestock Officers report very favourably on the progress of the scheme and the marked improvement in the young stock where premium bulls have been in use for some time. It is satisfactory to note the general and continued success of premium sires and their progeny at sales and shows. One of the Ministry's Livestock Officers reports that stock by premium bulls have been successfully shown at every show in his district, and at one of these shows every first prize was won by animals which were sired by premium bulls. In another instance twelve animals under two years old, sired by a premium bull, secured the highest average at the market on that day, and as a result of this success four new members joined the society in order to have the benefit of using this sire. Another of the Ministry's Livestock Officers recently attended a meeting of small holders for the purpose of explaining the advantages of the scheme, and at the close of the meeting eight of the number present guaranteed to advance £10 apiece to start a society and buy a pedigree bull. This decision was partly attributable to the fact that two farmers present at the meeting had seen for themselves the improvement resulting from work of another society in the district, and emphasizes the value to agriculturists of practice over precept.

In some dairying districts, even where calves are reared in considerable numbers, there is still much leeway to be made up. The high prices still commanded (and likely to be) for suitable bulls of dairy strain may partly account for this, and continued effort is necessary to convince such breeders that it is poor economy to continue using nondescript sires about whose breeding little or nothing is known.

There was again a drop in the prices of bulls, other than those of dairy type, purchased during the year under review, and the average price of all the bulls provided was consequently lowered. The following table shows the number of bulls of each breed subsidised and the average cost for the first year and last two years of the scheme :—

NUMBERS AND PRICES OF BULLS OF EACH BREED.

Breed	1914-15		1922-23		1923 24	
	No.	Average cost	No.	Average cost	No.	Average cost
		£ s. d.		£ s d.		£ s. d.
British Friesian	..	..	6	77 15 8	5	74 16 0
Devon	16	40 17 6	90	59 10 3	106	57 16 0
Guernsey	..	..	7	53 9 3	12	51 10 0
Hereford	63	33 7 6	84	58 3 4	100	50 19 0
Lincoln Red	33	31 10 0	94	63 14 11	101	55 11 0
Red Pole	..	..	1	78 15 0	..	..
Shorthorn	337	37 17 0	553	64 16 3	573	57 10 0
South Devon	6	36 11 6	17	58 11 6	15	47 5 0
Welsh Black	35	29 9 0	64	52 2 11	62	52 1 0
Other Breeds	7	29 4 6	..	..	..	..
All Breeds	497	36 0 0	916	62 11 9	974*	56 3 0

* 978 bulls were located, but grants in respect of 4 were in suspense at the end of the year.

As was the case in the preceding year the service fees varied from 2*s.* 6*d.* to 10*s.* 6*d.* It will be seen from the subjoined table that there was again a substantial increase in the number of bulls serving at 5*s.*, but the number serving at a higher fee remained about the same (*i.e.*, 277 compared with 271 in the previous year). The average service fee for all the bulls was 5*s.* 3*d.*

Service fees.

Year	2/6	3/	3/6	4/	4/6	5/	5/6	6/	6/6	7/	7/6	8/	8/6	9/	10/	Over 10/
1914-15 .	265	57	41	42	3	88	..	..	..	..	1	..	..	..	..	..
1922-23 .	50	40	28	84	10	430	3	53	2	10	141	7	8	2	45	6
1923-24 .	51	46	25	71	9	491	2	84	2	12	126	6	7	1	26	5

Boars. There was a satisfactory increase in the number of boars available during the year ended 31st March, 1924 (*i.e.*, continued from previous years with renewed grants or located in fresh districts during the year), the number being 638 as compared with 569 in the preceding year. The difficulty of forming Boar Societies is apparent in the fact that of the 638 boars available, 550 were provided by individual owners.

Boar scheme.

(Showing the number of boars subsidised during the past 10 years.)

Year*	Societies	Individuals	Total No. of boars
1st April to 31st March—			
1914-15	115	..	115
1915-16	180	..	193
1916-17	186	15	216
1917-18	172	92	261
1918-19	156	167	350
1919-20	120	225	399
1920-21	135	285	441
1921-22	113	416	550
1922-23	93	451	569
1923-24	78	541	638

* Including the period 1st February, 1914 – 31st March, 1914.

In several districts more applications for premium boars were received than could be met from the number of grants available. In other districts a strong preference for a local type of pig, not recognized as a distinct and established breed, has prevented the fullest use being made of the scheme. In some such districts efforts are being

made to register and form herd books, and to secure recognition from the Ministry for the purpose of the Boar Scheme. In this connection it may be noted that the Ministry has recently, after consultation with its Advisory Livestock Committee, extended this recognition to the Welsh pig.

As in the case of bulls, premium boars and their progeny have attained general success at sales and shows, the natural result of the improvement which has taken place in districts which have been served by premium boars for some years.

Increasing interest has recently been shown in the production of the most suitable type of pig for bacon factories, and efforts are being made to meet the requirements of local factories in this respect by encouraging the most suitable type of sires.

It will be seen from the following table that the average price of the boars located under the scheme during the year under review was £14. 6*s*. 2*d*., which was slightly lower than the previous year's average, *viz*., £15. 0*s*. 4*d*. The most popular breeds at present are the Large White, Large Black and Middle White.

NUMBERS AND AVERAGE PRICES OF BOARS OF EACH BREED.

Breed	1914-15 No.	1914-15 Average price £ s. d.	1922-23 No.	1922-23 Average price £ s. d.	1923-24 No.	1923-24 Average price £ s. d.
Berks	10	8 0 0	11	18 2 3	10	17 1 9
Cumberland	..	..	30	16 5 0	29	14 5 3
Essex	..	..	4	23 7 6	5	19 9 9
Glos. Old Spot	7	7 1 0	37	21 8 0	32	15 8 3
Large Black	18	7 5 6	141	14 12 7	138	13 4 4
Large White	64	7 3 0	199	13 13 10	250	14 11 9
Lincoln Curly Coat	4	8 4 6	31	12 3 10	35	11 16 10
Middle White	12	6 17 0	77	15 11 7	98	14 16 9
Large White Ulster	..	..	2	16 0 0	6	16 6 8
Tamworth	..	..	1	20 0 0	2	18 18 6
Wessex Saddleback	..	..	13	16 2 3	14	14 12 6
All Breeds	115	7 5 3	546	15 0 4	619*	14 6 2

* 638 boars were located, but grants in respect of 19 were in suspense at the end of the year.

The service fees varied from 2*s.* 6*d.* to 10*s.* Considerably more than one-half the boars served at a fee of 5*s.*, while a third of the remainder served at 7*s.* 6*d.* The average fee for all the boars was 5*s.* 5*d.*, a trifle lower than in the previous year.

SERVICE FEES.

Year	2/	2/6	3/	3/6	4/	4/6	5/	5/6	6/	6/6	7/	7/6	8/	8/6	10/	Over 10/
1914-15 .	21	62	10	5	6	..	2	..	..	..	..	..	..	..	..	..
1922-23 .	..	7	12	13	37	5	300	..	51	4	2	99	..	4	13	1
1923-24 .	..	9	9	12	44	1	368	1	58	2	4	104	..	2	5	..

Milk recording. No part of the Livestock Scheme has made more satisfactory progress than milk recording. Notwithstanding the many serious obstacles arising out of the abnormal conditions prevailing during the first five or six years of the operation of the scheme, the movement has continued to spread until at the present time practically every county in England and Wales has its own recording society or societies, and no district is outside the radius of one or other of these societies. During the year under review 416 new members, owning 10,000 cows, have been enrolled, and in view of the hampering restrictions consequent on the serious outbreaks of foot-and-mouth disease over a large part of England and Wales, this increase may be considered satisfactory. The following table shows the growth of the movement since its commencement :—

Year*	Societies	Members	Herds	Cows
1st April to 31st March—				
1914-15	16	264	306	7,331
1915-16	20	350	398	9,811
1916-17	22	441	495	12,950
1917-18	25	503	555	14,404
1st October to 30th September—				
1917-18	27	639	708	19,793
1918-19	38	1,191	1,332	37,880
1919-20	46	2,075	2,312	61,323
1920-21	52	3,328	3,664	97,903
1921-22	55	3,949	4,362	117,023
1922-23	55	4,365	4,767	127,151

* Prior to 1st October 1917, there was no uniform year for societies.

Average yield of herds recorded. The annual returns furnished by the 55 societies for the recording year ended 1st October, 1923, show that of the 127,151 cows and heifers recorded, 54 per cent. were cows which had been retained in the herds for the full year, and that the average yield of these 68,349 cows was approximately 7,000 lb., an appreciable increase over the averages of previous years.

Many societies averaged considerably more; for instance, the Hampshire Society with 3,251 full-year cows averaged 7,601 lb., and the Essex Society, which for the year ended October, 1918, had only 407 full-year cows yielding on an average 6,531 lb., has shown remarkable development, having had in the last milk-recording year 4,388 full-year cows whose average yield was 7,499 lb., a tenfold increase in membership and of approximately 1,000 lb. in the average yield of the cows.

When the milk-recording movement was initiated by the Ministry the thousand-gallon cow was talked about and sometimes got into print, and though the object of the scheme is not to encourage the production of phenomenal milk yielders, it may be of interest to record that last year 125 herds—not cows—averaged 10,000 lb. per cow or over: good evidence of the value of milk recording and of the results obtained by careful weeding out, selection and breeding.

The following statement compares the average annual yield of (1) all cows and heifers recorded, and (2) of the cows recorded for the full year for each year since the uniform milk-recording year was fixed :—

Year	No of societies	Particulars of all cows and heifers recorded			Particulars of cows recorded for full year			
		No of cows and heifers	Total yield	Average yield	No. of cows	Percentage of Total cows	Total yield	Average yield
1st October to 1st October			gal.	gal.			gal.	gal.
1917-18 . .	27	19,793	8,426,958	426	8,775	44	5,255,923	599
1918-19 . .	38	37,880	16,204,941	450	17,989	47	10,543,516	·79
1919-20 . .	46	61,323	29,344,887	479	27,266	44	17,363,347	637
1920-21 . .	52	97,903	48,512,380	495	48,248	49	30,892,620	640
1921-22 . .	55	117,023	60,163,617	517	63,318	54	41,208,073	651
1922-23 . .	55	127,151	67,904,224	534	68,349	54	46,956,565	687

While the total average yield continued to improve steadily, a much more marked advance is shown in individual herds as a direct result of the more systematic and economic management following the adoption of milk-recording. As an instance of this, in the returns for 33 of the herds (of over 20 cows) of one society which have been recorded from 1917-18 to 1922-23, there was an average increase in the yield per cow of full-year cows of 92 gallons. The maximum increase shown by a herd was 234 gallons per cow.

Milk record certificates. The number of milk record certificates issued to members was 2,065. This number represents 1·62 per cent. of the total number of cows recorded. Of the 2,065 certificates issued, only 155 were for yields of less than 6,000 lb., 1,367 were for yields between 6,000—10,000 lb., and 543 were for yields of over 10,000 lb.

Register of dairy cattle. The seventh volume of the Ministry's Annual Register of Dairy Cattle,[1] covering the year under review, has been issued. It contains particulars of 1,321 cows (belonging to 271 members) in respect of which certificates have been issued by the Ministry showing that they have certified yields of 8,000 lb. or over of milk during the milk-recording year ended 1st October, 1923, or an average of 6,500 lb. for that year and one or more preceding consecutive years. Twelve recognized breeds or types are represented in the seventh volume, and there are, in addition, 57 cross-bred cows (*i.e.*, cows which do not conform to one recognized breed or type), whose milk yields have justified their inclusion under the standard required. Of the 1,321 cows entered in the seventh volume, 1,165 gave over 8,000 lb. of milk during the year, and 156 were entered on an average of 6,500 lb. or over. Of the 1,165 cows which were entered on one year's yield, 482 gave over 10,000 lb.

The seventh volume of the Register contains the second list of cows in respect of which certificates of merit have been issued certifying that such cows have yielded not less than 24,000 lb. of milk over a period of three consecutive years and have calved at least three times during that period. This section, and the sections for dairy bulls, have been better supported than was the case in the previous volume, and it is hoped that in course of a few years the information given in these sections will constitute a valuable part of the register. Steps are being taken by the Ministry to popularise the register and to increase its scope and usefulness to all classes of dairy farmers.

After consultation with its Advisory Livestock Committee the Ministry has made certain important changes in the conditions of entry into the Register, the principal of which are :—(1) the issue of a Certificate of Milk Record will not be required as a condition of entry ; (2) entry will be made on the basis of one year's yield only.

The alterations have been made with the object of securing a more comprehensive and valuable book of reference for the use of members of milk-recording societies and others interested in dairy cattle, and Vol. 8 of the Register will contain entries of approximately 5,000 of the highest yielding cows of all breeds and types. A copy will be presented free to each member of a milk-recording society who records under the Ministry's scheme.

Cost of milk-recording. The marked tendency for costs to increase which had been noticed in previous years was checked in the year ended 1st October, 1922, and, as was anticipated, the results for the year under review show a distinct

[1] Price 2*s.* 6*d.*, post free from the Ministry.

reduction in costs, notwithstanding increased activities on the part of societies. About 30 per cent. of the societies have been able to reduce their levies per cow by 6*d*. or more, and, with very few exceptions, societies are in a sound financial condition.

Commercial value of milk-recording. The commercial value of milk-recording continued to be demonstrated by the prices realized at sales for recorded non-pedigree cattle and their progeny, and although, as was anticipated, the exceptional prices realized during the boom period of 1921 were not so evident, it is noteworthy that milk records are much more frequently seen in sale catalogues and asked for in private transactions than was formerly the case.

Advice on rationing. Much greater interest has been evinced in the schemes instituted by the County Agricultural Organizers for the economic feeding of dairy cows and butter fat testing. The very useful advice and assistance given by the Organizers are much appreciated and the adoption of balanced and economical rations should prove of great value—financial and otherwise—to members of milk-recording societies.

Calf marking. The Ministry's Calf and Bull Marking Schemes, the adoption of which is optional, have now been taken up by all but two societies, and interest is steadily growing as members realize the value of officially identifying the progeny of their recorded stock. The number of animals marked under this scheme during the year was, 12,647 as compared with 11,517 during the preceding year.

Statement giving particulars of 55 milk-recording societies operating during the year ended 1st October, 1923.

(The societies are arranged in order of total number of animals recorded.)

Name of society	Number of members	Number of herds	Total number of animals recorded	Number of cows recorded for full year	Average yield of cows recorded for full year
					lb.
Essex	215	238	7,902	4,388	7,499
East Sussex	190	229	6,730	3,595	7,311
Hampshire	176	194	6,166	3,251	7,014
Yeovil and Shepton Mallet . .	150	171	5,404	3,191	6,749
Berkshire	135	150	5,378	2,788	6,845
Hertfordshire	159	178	5,290	2,681	7,200
Kent	163	186	4,974	2,613	7,200

Statement giving particulars of 55 milk-recording societies operating during the year ended 1st October, 1923—contd.

Name of society	Number of members	Number of herds	Total number of animals recorded	Number of cows recorded for full year	Average yield of cows recorded for full year
					lb.
North West Wilts	166	119	4,714	2,736	6,902
Dorset	77	103	4,568	2,720	6,599
Surrey	170	180	4,360	2,174	6,796
Norfolk	144	165	4,253	2,392	7,601
West Sussex	109	119	3,738	1,815	7,255
Oxford	102	109	3,666	1,962	6,950
Salisbury	61	86	3,654	2,338	7,524
Lancashire	131	139	3,574	1,485	6,735
Warwickshire	121	131	3,137	1,604	7,070
Leicester	100	103	2,718	1,417	7,414
Suffolk	107	116	2,513	1,642	7,365
South Devon	97	106	2,452	1,198	6,309
Northants	91	103	2,320	1,271	6,668
Yorkshire	140	141	2,317	1,018	7,333
Shropshire	70	78	2,163	1,383	7,309
Cambridgeshire	83	91	2,150	1,239	7,415
Cheshire	58	64	2,141	1,031	7,152
Cumberland	141	143	2,026	891	6,089
Stafford	71	75	1,837	982	7,519
Nottingham	53	55	1,764	888	6,821
Buckingham	66	71	1,709	835	8,239
Derby	48	51	1,685	869	7,329
Bristol and Bath	76	77	1,537	831	7,281
Denbigh and Flints	70	72	1,459	901	6,685

Statement giving particulars of 55 milk-recording societies operating during the year ended 1st October 1923—concld.

Name of society	Number of members	Number of herds	Total number of animals recorded	Number of cows recorded for full year	Average yield of cows recorded for full year
					lb.
Worcestershire	62	65	1,416	748	6,948
Peak	57	57	1,266	480	7,004
Warminster and Mere	27	31	1,191	877	6,849
Cadbury	37	45	1,152	761	6,741
Tees Valley	30	37	1,080	438	7,334
East Devon	64	64	1,016	467	6,716
Bedfordshire	36	37	945	510	7,436
Kendal and South Westmorland	47	47	856	386	5,841
Frome	20	20	853	567	6,431
Cornwall	50	50	777	446	6,020
North Somerset	31	35	764	473	6,898
Lincolnshire	33	36	755	361	7,175
Anglesey and Carnarvon	60	62	753	432	5,454
Allendale	40	41	741	433	7,034
United Counties	47	48	732	421	6,544
Monmouth	34	36	627	327	6,511
Herefordshire	27	27	620	329	7,026
Campden, Moreton and District	33	33	575	366	6,940
Gloucester and District	32	34	563	295	6,848
Melton Mowbray	26	26	556	295	6,682
Cotswold	25	25	523	359	7,474
Montgomery	23	23	421	223	6,031
Highbridge	15	16	382	226	7,048
Glamorgan	29	29	288	Commenced 1st April 1923.	
TOTAL	4,365	4,767	127,151	68,349	7,042

Sheep. Since 1919 the Ministry has given some financial assistance towards the improvement of Welsh Mountain Sheep. Grants up to a maximum of £10 for each ram provided, at the rate of 3*s.* 4*d.* per ewe served, were made to 14 societies in respect of 17 approved pedigree rams, during the year ended 31st March, 1924. The average hiring fee of the rams was £9 13*s.* and the average service fee 1*s.* 5*d.* The number of ewes served was 1,020, an average of 60 per ram.

The scheme, which is in its infancy, promises well, and one excellent result of its operation has been that several members of societies have purchased pedigree rams of their own.

Heavy horses. It was possible to revive the grants to Heavy Horse Societies, which were discontinued after 1921, owing to the urgent demand of economy at that time. As the announcement that grants would be available was only made in February last, full advantage could not be taken of the scheme for the service season of 1924. It is confidently anticipated, however, that next year it will be possible to continue the good work accomplished by the scheme during the years 1914–21.

The following are the principal memoranda used in connection with the livestock operations of the Ministry, and copies of them can be had free of charge on application to the Secretary, Ministry of Agriculture and Fisheries, 10, Whitehall Place, London, S.W. 1 :—

Leaflet 282.—Scheme for Improvement of Livestock.
Leaflet 146.—The Value of Records of the Milk Yields of Cows.
No. 609-T. L.—Bull Grant Regulations.
No. 392-T. L.—Milk-recording Regulations.
No. 466-T. L.—Boar Grant Regulations.
No. 86-T. L.—Heavy Horse Regulations.

Light horse breeding. The administration of the Light Horse Breeding Scheme was transferred to the War Office on 1st April, 1924, and the following report on the year 1923-24 marks, therefore, the termination of the Ministry's active interest in the scheme which was inaugurated in 1910, and has thus been in existence for 14 years. The operations of the scheme during that period have been described in the annual reports published by the Ministry.

During the year 1st April, 1923– 31st March, 1924, the scheme was carried on by the Ministry on the usual lines. It was satisfactory that sufficient stallions of the requisite merit were forthcoming at the Thoroughbred Show in 1923 to enable the full number of King's and Super Premiums to be awarded, which was not the case in the preceding year.

Premiums awarded for 1923 season. The following premiums were awarded for the season 1923 :—12 Super Premiums, 48 King's Premiums and 15 Ministry's Premiums (all thoroughbred horses except 3 Ministry's Premiums which were awarded to 1 Hunter stallion and 2 Cleveland Bay stallions), 5 Riding Ponies, 18 Welsh Cobs,

3 Welsh Roadsters, 4 Dales Ponies, 5 Fell Ponies, 15 New Forest Ponies and 40 to Mountain Pony Stallions in Wales.

Service season, 1923. The service season of 1923 showed considerable improvement on that of 1922, the average number of mares served by both the King's and Ministry's premium stallions showing a marked increase. The numbers of mares served by the various classes of stallions were as follows :—

—	No. of mares served	Average per stallion
12 Super Premiums	966	81
48 King's Premiums	3,437	72
15 Ministry's Premiums	886	59
5 Riding Pony Premiums	208	42

Foaling results from service season, 1922. The foaling results from the 1922 service season showed a slight improvement on the previous year. The foaling percentage of stallions is calculated upon returns furnished to the Ministry by the mare owners, and the results from the 1922 service season were as follows :—

—	Number of mares served in 1922	Number of returns furnished to Ministry	Average percentage of foals
12 Super Premiums	855	841	56
45 King's Premiums	3,033	2,952	53
15 Ministry's Premiums	872	845	54
5 Riding Pony Premiums	205	201	63

The highest percentage (73) was obtained by "Ballyvodock," now owned by Mr. Terry O'Brien, Ballyvodock, Midleton, Co. Cork.

Thoroughbred show, 1924. At the request of the War Office the Ministry made the usual arrangements in conjunction with the Hunter's Improvement Society for the Annual Show of Thoroughbred Stallions for the purpose of awarding premiums to stallions for the service season 1924. The show was held at the Royal Agricultural Hall on 4th, 5th and 6th March, and the Judges were Mr. Ernest Bellaney and the Hon'ble Alexander Parker. The number of entries was 94, seven more than in 1923, and of these, 30 were stallions which had not previously been shown. The full number (60) of Premiums (including 12 Super Premiums) was awarded and the King's Cup was won by "Scarlet Rambler" belonging to Captain T. L. Wickham Boynton and Henry A. Cholmondeley, the Reserve horse being "Gay Lally" belonging to the Compton Stud, thus reversing the positions occupied by these two stallions during the previous three years.

Horse Breeding Act, 1918. During the licensing year 1st November, 1922, to 31st October, 1923, there was again a marked decrease in the number of stallions licensed under this Act, the number being 2,761 as compared with 3,479 in the preceding year. The proportion of stallions for which licenses were refused remained almost the same. There were 136 refusals, 15 of which were after appeal, the numbers for the previous year being 165 and 16 respectively.

Of the 2,761 licensed stallions, 2,512 were pedigree animals and the remaining 249 were horses that were not entered or accepted for entry in any recognized stud-book.

The following tables show the number of stallions of each breed concerned that were licensed or rejected, and the number of refused licences in respect of the various prescribed diseases or defects :—

Number of stallions licensed or refused.

	Pedigree		Non-Pedigree *	
	Licensed	Refused	Licensed	Refused
Heavy				
Shire	1,568	88	66	3
Clydesdale	185	13	6	1
Suffolk	186	5	1	1
Percheron	47	1	..	..
Others	..	..	61	2
Light				
Hackney	179	8	30	..
Thoroughbred	140	6	3	..
Arab	22	2	4	..
Hunter	6	..	5	..
Cleveland Bay	7	..	..	..
Yorkshire Coach	2	..	1	..
Welsh Roadster	3	1	1	..
American Trotter	1	..	7	.
Others	..	..	12	..
Ponies (including Welsh Cobs)	166	2	52	3
Total	2,512	126	249	10

* Non-pedigree stallions are arranged as far as possible under types.

Number of stallions rejected for the prescribed diseases and defects.

Roaring	29
Whistling	41
Sidebone	21
Cataract	12
Ringbone	8
Bone Spavin	10
Defective Genital Organs	2
Stringhalt	4
Shivering	7
Navicular Disease	1
General Unsuitability	1
TOTAL	136

Twenty-three appeals were made against refusals of licences, and in 8 cases these were successful.

Notwithstanding the decrease in the number of stallions licensed, the Ministry has information which suggests that the number of unsound stallions which formerly travelled at very low fees, and which constituted the most serious hindrance to the grading up of horse breeding, have been practically eliminated from the road. Since the Horse Breeding Act came into force the Ministry's inspectors and livestock officers and the police have endeavoured to secure observance of the Act by stopping stallions on the road and requiring the production of the licenses, and in cases where the regulations have been infringed proceedings have been taken by the police. The fact that the number of prosecutions is steadily declining is evidence of a more general knowledge of and compliance with the Act on the part of stallion owners.

TECHNICAL CONTROL IN AGRICULTURE.*

BY

H. M. LEAKE, M.A., Sc.D. (Cantab.), F.L.S.

Let me draw a contrast. I well remember a conversation some twenty-five years or more ago when the advantage of the employment of a works chemist in a cement works was under discussion. The owner was opposed to the suggestion and his argument was, briefly, as follows : by the time the chemist had completed his analysis of the clay and chalk which went to the composition of the cement, these two had been mixed and appeared as the final product. That was, as I have said, some twenty-five to thirty years ago and expressed the then too common attitude of the producer to technical control. I now turn to the other picture. A short time ago a well-known planter was visiting the Imperial College. In the course of discussion the question of the employment of technical control on sugar estates arose and he expressed himself somewhat on these lines ; I give my chemist good pay, free hours, electric light and all I can towards his comfort and he is still the cheapest man in my employ. That expresses the practical view held at the present time by the vast majority of producers employing technical processes and the contrast is very marked. But even in the latter case it is doubtful whether in the balance-sheet full credit is given to the value of the body of workers of whom, in the above cases, the technical chemist is the representative. In the last twenty-five years great changes have come over the cement industry ; the open vats and simple kiln have been replaced by the rotary kiln, and these changes are the joint work of the research chemist and the engineer. In the case of sugar, the substitution of the muscovado process with its open pan by the central factory with its triple effect is the result of the skill of the engineer and of chemical research on the constituents of the juice and on the inversion changes which take place during boiling. On the cultivation side again, the technical chemist financially justifies his existence by control of the manure supplies but in the balance-sheet no credit is given to those large numbers of workers by whose study the principles and the systems of manuring have been worked out.

I have, however, digressed for I am not at the moment concerned to justify the research worker. My aim is to draw attention to the change in attitude towards the technical worker in industrial processes and to compare this with agricultural

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development in the same direction. For while this change has taken place in the industrial world but little development is to be noticed on the agricultural side. As a body the planter or farmer keeps a simple system of accounts and neglects the systems of costing employed by the manufacturer. The work of Orwin and the Agricultural Costings Committee had no marked influence and few practical farmers accurately cost out the value of any new practice.

This defect affects even more fundamental issues than the industrial processes to which I have made reference, for it refers to office organization and systems of book-keeping, branches of the manufacturing organization the importance of which has long been recognized in the industrial world. And if such defects are found at this stage of agricultural organization it is hardly surprising that the value of technical control in agriculture has generally been missed, for the recognition of values is in such cases very largely a matter of accurate costing.

What then, is the substance of technical control in agriculture? This must depend in large measure on the type of cultivation employed. It will take one form in the case of plantations growing tea, rubber, cocoa and the like which are perennial orchard crops; it will take another form in the case of mixed farming with short season crops as sugar, cotton, oilseed and so on. It will take one form if the land is owned directly and worked by paid labour, it will take another if the land is leased and worked on a tenancy basis. In the former cases it takes the form of actual skill in the practical handling of the land and of the stock and crops which the land carries; in the latter cases this aspect is not so important and technical skill will be re-inforced by a knowledge of the relationship between landlord and tenant, of the organization of credit and co-operation and of the best markets for buying and selling.

The importance of technical control as it applies to the plantation is fairly generally recognized though much remains to be done to introduce into practice the results of recent research. When, however, we turn to the question of estate management and tenancy, technical control is mainly conspicuous by its absence, One of the main difficulties of small holdings, whether held directly or under lease, lies in the provision of capital. With a correct relationship between landlord and tenant the latter should look to the former to supply his needs in this respect. The subject of the relationship between these two is one that still offers a large field for investigation but, though the main principles are known, they are rarely adopted in practice.

Before such control can be exercised, it is necessary to train men in the principles. Tropical development will be based largely on a tenancy system and the rapid progress now being made in the opening up of tropical areas demands men and trained men, if the correct relationship between the foreign agent of development and the indigenous tiller of the soil is to be established. Even established estates working on a tenancy basis will derive benefit from control of this nature. It is in this matter that the Imperial College can do good work. By working an

estate with a system of tenancy and by a study of this relationship, both practical and theoretical, instruction will be rendered available for the training of the body of men now needed. Just as the recognition of the need of technical control in industry was slow in coming, so the recognition of this need, as I have defined it, for agriculture, may be slow to develop, but I look forward to a time when the owners of estates will be making of such managers the same observations as were recently made of the chemist by the planter to whom I have made reference above.

production has now grown until it is in the neighbourhood of 25,000 tons per annum.

New Zealand. The New Zealand hemp industry dates from the introduction of machinery for stripping and cleaning for export. The fibre had long been known to the Maoris who produced from it not only cordage and fishing twines, but also garments so fine in texture that the British settlers believed they were made from flax. Attempts to prepare the fibre mechanically to the high degree of perfection obtained by the Maoris by hand labour did not succeed, so that the comparatively coarse fibre prepared from this plant, *Phormium tenax*, is devoted exclusively to cordage and twine purposes.

Mauritius. This small island has long been famous for a type of fibre which has not been produced to quite the same perfection in any other quarter of the globe. From the leaves of the *Fourcroya gigantea* the islanders extracted a fibre from four to six feet long, softer and finer in texture than sisal or New Zealand, white in colour, and well adapted for the production of certain fancy articles in the cordage and twine trades. An attempt was made before the war to introduce machinery, a Krupp decorticator having been imported by the Agricultural Department, but it did not succeed in stimulating the production. The high price of sugar, combined with the low value of fibre, has during the last ten years discouraged the production of Mauritius hemp ; but the demand is again reviving, and it may be anticipated that the industry will continue on the same old-fashioned lines of small production and the cleaning of material by hand.

Manila Hemp. Manila hemp is the fibre most adapted for the manufacture of ropes for marine purposes, as it resists the corrosive influences of sea-water better than any other fibre. At present its production is confined exclusively to the Philippine Islands, and the crop is steadily increasing, as will be seen from the following table :—

TONS AND VALUE OF MANILA HEMP EXPORTED.

	1921	1922	1923
United States	36,487	83,283	87,610
United Kingdom	45,968	61,213	70,231
Elsewhere	36,644	40,076	48,410
	119,109	184,572	206,251
Value on the basis of "J" grade	£4,883,469	£6,090,876	£6,806,283

No part of the British Empire has so far succeeded in producing this fibre, although experiments have been made in various districts whose climatic conditions approximate those of the Philippines.

Cannabis sativa. We now come to the true hemp, *Cannabis sativa*, the oldest textile fibre. In years gone by England grew hemp in Dorset, Somerset, and Lincoln,

where it was locally spun and twisted into ropes and twines, thus constituting the nucleus of many important branches of business, some of which still flourish, Bridport is still an important centre, especially for fishing twines; but it no longer secures supplies from local sources, these having been supplanted last century, first by Russian hemps, and later supplemented by the Italian variety of the same plant. These two classes of fibre produce the highest grades of polished twine and ropes for marine purposes.

There is no record of any serious effort within the British Empire to produce hemps to take the place of Russian and Italian varieties. In Russia the system of preparing the material by growing it in small patches, and cleaning and preparing it by the hand labour of the grower and his family, is analogous to the system in vogue in India for the preparation of jute. No machinery whatever is used, yet before the war about 124,000 tons per annum were grown on two million acres, of which 64,000 tons were exported and 10,000 to 15,000 came to England. The Russian variety is especially strong, of a light-green colour, and it averages in length four to six feet. Since the war this trade has been dislocated, but is slowly reviving.

The cultivation of hemp in Italy is conducted on highly scientific lines, especially in Northern Italy, where farmers employ the very latest agricultural machinery and utilize the scientific information they receive from the agricultural committees, who issue reports on the nature of the soil and the class of fertilizer best adapted to each particular district. Further, they take germination tests of seed, and generally supervise the cultivation. They provide machinery on co-operative principles, both to cultivate the crops and to prepare the fibre for market. The scutching machinery is sent from farm to farm, thus relieving small growers of the expense of the purchase and upkeep of fairly complicated and expensive machinery. Italian hemp attains a height of ten or even twelve feet. The ideal conditions of climate during the growing and retting season facilitate the production of pure lustrous fibre of a light colour and of high tensile strength.

Flax (*Linum usitatissimum*). The war brought us perilously near a cessation of supplies of flax essential during the war, and no less essential for ordinary daily consumption in peace time. Various committees were appointed during the years 1915 to 1918 to report on substitutes for flax, and to investigate the possibility of its production within the Empire. Lord Colwyn's Committee reported that there were no real substitutes for flax. Encouraged by the steady increase in price during the war, the experimental cultivation of flax was extended to various parts of the Empire. Ireland, which is the only country within the Empire which has retained the cultivation of flax on a commercial scale, increased its area from 59,305 acres in 1913 to 143,385 in 1918; but this still left a lamentable shortage, seeing that Russia had normally supplied some 80,000 tons per year, or approximately 85 per cent. to 90 per cent. of the total consumption in the United Kingdom. Unfortunately the area has since 1918 been seriously reduced as the result of low prices and poor demand.

In 1913 I was instrumental in starting flax cultivation in East Africa. It had been ascertained that, in the highland area of Kenya some 7,000 feet to 8,000 feet above sea-level, a quality of flax could be produced which compared favourably with the medium grades of Belgian, and which was on the whole decidedly superior to the average quality obtainable from Russia. The cultivation was readily extended until the year 1920, when the area was increased to 27,174 acres, and it really looked as though Kenya might become an important source of supply of flax. Unfortunately for the industry and for the Empire, the serious depression which set in brought down prices from about £400 to £70 per ton, resulting in an entire dislocation of this budding industry and the closing-down of a large number of plants which had been erected in this new colony on the most improved lines and with the very latest machinery.

While Kenya was developing flax cultivation, in Canada, where for many years past a nucleus of flax production had been preserved in Ontario, the banks and other financial institutes were liberally financing the production of flax on an increased scale. The results, as far as quality is concerned, were satisfactory; but the drawback in Canada is unquestionably the high rate of wages, which raises the cost of production to a point which can scarcely hope to compete with the Russian and African product.

Australia stands in the same position. Good flax was grown there during the war, and was eagerly absorbed by local manufacturers, who found themselves at a loss to obtain any of the supplies from Europe, which were jealously guarded by the various War Departments. The high wages in Australia, however, stand as a barrier against the production of flax or hemp, as long as existing conditions continue.

NOTES

SULPHATES FOR MONSOON CROPS IN SOUTH BIHAR.

In 1923, a strain of *kalai* (*Phaseolus mungo*) was found to suffer from severe chlorosis. Seeds were collected from diseased plants. and in 1924 an experiment was tried at Sabour to test the effect of certain metallic salts, whether they would be able to improve the condition of the crop and prevent the yellowing. The salts tried included the following applications per acre : Lead carbonate (20 lb.), zinc sulphate (20 lb.), manganese sulphate (100 lb.), magnesium sulphate (200 lb.), lime (200 lb.), gypsum (200 lb.), boric acid (5 lb.), potassium iodide (5 lb.), sodium chloride (20 lb.).

Although the yellowing of the leaves was not controlled in any of the experimental plots, the result was remarkable in showing the effect of the sulphates. In all the plots to which sulphates were applied the growth of the healthy plants was distinctly more vigorous, gypsum giving the most favourable result. Even the small application of zinc sulphate at a rate equivalent to 4 lb. of sulphur seemed to produce a striking improvement on the growth. Whether this was wholly due to the sulphur or partly due to the presence of the basic ion will be tested by further experiments on the effect of zinc sulphate as against sulphur and some other zinc salt on healthy plants. No difference, however, was perceived between plots which were unmanured and which were treated with other salts than sulphates.

This experiment indicates that application of sulphates, and particularly of gypsum, will probably be found useful in South Bihar. Sulphur is one of the essential elements of plant life. The requirements of the plant in respect of this element were, however, believed to be so small that the soil was always supposed to be plentifully endowed with it. In fact where the application of a sulphate like gypsum produced any good effect the result was believed to be not so much due to sulphur as to the physical improvements in the soil caused by it and to an interaction between the base (lime) and the insoluble bases in the soil resulting in the production of soluble plant foods. The Bihar soils in many places contain practically no sulphates and at most places less than 0·001 per cent. In recent years attention in this province has been drawn to the improvement in the crop production by the application of sulphur or sulphates and one of the tangible results achieved has been the effect of the application of sulphur and gypsum on the sulphate-starved soils of Chota

Nagpur[1] and South Bihar. The practice of applying sodium sulphate (*khari nimak*) to paddy to improve its condition has long been known. The experiments made by the Howards at Pusa show that the effect of the application of sulphuric acid and sulphur was distinctly better on cotton and indigo[2] than that of superphosphate, so that the increased production due to the latter is presumably not wholly due to the phosphate in it and a considerable part is probably played by the calcium sulphate it contains. Further tests of varying quantities of sulphur on a variety of leguminous monsoon crops will be taken up. [M. N. Ghosh and S. K. Basu.]

SHORT-PLANTING OF SUGARCANE.

This term is applied to the procedure adopted when the rapid multiplication of a selected cane is the object in view. It is calculated that by the use of this method it has been possible to get selected canes out to the growers in bulk in the fourth year instead of after six or seven years in the usual course. This saving of time is of the utmost importance, as not only does it enable an improved cane to be quickly taken up but it also allows any cane which may suddenly develop unsuitable characters to be replaced over a large area in a short time. The idea originally struck the writer when observing the method adopted in the Java hill nurseries for securing the maximum amount of seed. In Java, with constant irrigation and a cane growing throughout the season, the operation is comparatively easy. In North Bihar it has several difficulties to contend with. Firstly, it is absolutely essential that the cane should be grown under irrigation and forced along during the hot weather. Secondly, to secure optimum results the monsoon must break early as the cane must have three weeks' monsoon conditions before it is cut. If cut immediately at break, nothing like the same amount of material will be obtained. Lastly, it has got to be planted out on high land, very shallow, and done well. With all these conditions favourable it will be found that seed from one acre will plant 6 in August and this six acres cut in February will afford planting material for 36 acres which in August following will plant out 216 acres and so on. This enables any large grower to obtain a seed nucleus for estate planting in one year. It is also extremely useful in filling up the gaps in the main crop, as all places near the edge of the crop which have failed or gone out in the hot weather can be planted from material cut from the strongest part of the crop in August. This planting will give excellent seed material the following February.

Seed from short-planted cane is invariably excellent and the amount of rejections comparatively very small. Experiments have shown that its germination is earlier

[1] *Agri. Jour. Ind.*, XV, 1916, pp. 310-311.
[2] *Agri. Jour. Ind.*, XVIII, 1923, pp. 148-153.

and growth stronger. The ideal method of obtaining seed for a large estate would be to maintain an area of short-planted cane to draw from and thereby separate cane grown for sugar from cane grown for seed, as the riper a cane is the less suitable it is for seed.

The operations when short-planting are simple. The first lot of cane when cut after the break of monsoon should be cut completely down, all top which does not show colour should be cut off. There is no need for the eyes to be swollen. They may be practically invisible and yet will germinate perfectly, provided the cane is formed and shows colour. There is no need to plant the sets eye to eye as the internodes will be comparatively short. It is most important to plant shallow and manure well. Previous cultivation should be good but can be the minimum as there is no lack of moisture, and if the cane is well manured at planting it does not matter what crop stood on the land previously, provided the land is fairly clean, so that the cane will get a start over the weeds. It is essential that short-planting in the rains should be done in Bihar by the end of July or the beginning of August at the latest. Cane planted later on does not come on so well with the result that the required planting material is not forthcoming. [WYNNE SAYER]

A NEW VIEW OF SOIL FERTILITY.

PROF. W. F. GERICKE of the University of California certainly seems to have developed a refreshingly novel point of view in relation to the problem of soil fertility, to judge from a preliminary note published in *Science* for 4th April, 1924, which has just been brought to our notice. Pointing out that the rapid growth of a crop often produces a temporary depletion of some essential soil constituent, he investigated by the water culture method the effect upon the growth of a plant of a period in which the salt supply provided lacked one essential element. The striking result was obtained that after plants had grown for one month in complete nutrient solution, a great enhancement of growth, increase in weight, and advance in date of maturity resulted from the transfer to solutions *devoid of potassium*. In the light of these experiments Prof. Gericke attempts a reinterpretation of the results obtained by Stewart (*Journ. Agri. Res.*, 12, 311-368, 1918), in which it was shown the barley crop very rapidly depleted the soil of nitrogen in the cases where large crops were obtained. From other water culture experiments Gericke had reached the conclusion that the presence of the nitrate ion materially affected the availability of the potassium ion to the plant, and he, therefore, inclines to associate these large yields in soils early depleted of nitrate with these new experiments in which lack of available potassium after the first few weeks of growth favours increased growth and yield. Needless to say, potassium, and indeed the full supply of nutrients, proves to be essential during the first few weeks of the plant's growth. Prof.

Gericke reports similar improved development and yield in plants transferred, after four weeks in full mineral solution, to media devoid of phosphorus. [*Nature*, No. 2870.]

THE CO-OPERATIVE MOVEMENT IN DANISH AGRICULTURE.

The following notes on the co-operative movement in Denmark, taken from the Annual Report by the Commercial Secretary at the British Legation, Copenhagen, may be found of interest :—

The first supply association was founded in a Danish town in 1866, and was based on the supply of goods to the working population at market prices, and the distribution of profits in proportion to the value of the goods purchased. In the course of time the movement spread and there are now some 2,000 supply associations throughout the country, both in the towns and in the rural districts, with a membership of about 350,000.

In connection with these supply associations, a "Joint Association of Denmark's Supply Associations" was founded in 1896, for the purpose of making the wholesale purchases for the various supply associations. In the course of time this central association founded a number of industrial undertakings (tobacco, chocolate, soap, margarine, bicycles, rope, knitted goods, leather and footwear, certain kinds of iron goods, and chemical technical articles) for the supply of the goods required, the turnover of these factories amounting in 1921 to Kr. 35,000,000, while in the same year the turnover of the joint association totalled some 175,000,000 kroners.

In 1898 was founded a Co-operative Fodderstuff Purchasing Association, and now between 35 and 40 per cent. of the country's imports of fodderstuffs (oilcake, maize and particularly in 1923, barley) are handled by such associations. Similarly, the Danish Co-operative Fertilizer Association (founded in 1901) supplies fertilizers to some 1,600 local societies throughout the country, with a membership of about 80,000 farmers. The central institution purchases and distributes to the member societies, on the basis of mutual guarantee, the extent of which is dependent on the size of the agricultural district in question.

Other articles required by the agricultural community are handled on co-operative lines, of which mention may be made of fuel and seeds.

The application of the co-operative principle to agriculture is, in Denmark, most characteristically shown in producing associations—co-operative dairies, "slaughteries" and egg collecting associations.

The Danish Co-operative Dairy Association was founded in the eighties with the object of extending to the smaller farmers the advantages to be gained from the production of milk in bulk, by improving the level and quality. The method employed is for a number of farmers in a district to combine to erect a dairy, the capital for the construction being advanced by a local bank on the basis of the absolute

liability of the interested parties. In this manner, upwards of 14,000 co-operative dairies have been erected in the country which to-day handle nearly 80 per cent. of the milk output, amounting to some 3,500,000 tons per annum. The farmers, who are bound to deliver all their milk to the dairy of which they are members, are paid by the dairies on what amounts in practice to the actual butter fat contents of the milk delivered. The dairies pay all overhead charges, such as transport, so that in this respect all the members of a dairy are equally placed, whether their farm lies far from or near to the dairy. Of the butter produced in these dairies, some 30 per cent. is moreover sold by the Butter Export Association, the remainder being handled by private farms.

The 46 co-operative "slaughteries," founded on similar lines, now handle about 90 per cent. of the total bacon production of the country. The output is mainly sold through British firms, but one co-operative selling association exists comprising nine "slaughteries." The co-operative "slaughteries" also interest themselves in the improvement of the stock by the establishment of stud farms and the publication of pedigrees, etc.

As regards eggs, the Danish Joint Egg Export Company has a membership of about 500 egg associations throughout the country with some 50,000 members. These members are bound to deliver eggs stamped so that they can be traced back in case of complaint.

Further, a Joint Cattle Export Association exists embracing a number of local associations throughout the country, the members undertaking that their sale of cattle, outside their own district, shall be made through the association. The cattle in question are delivered to the society on a fixed day in the week, and the farmer receives the estimated value, less a small working commission to the association. The cattle are then sold by the association, at the best terms obtainable, and at the annual balancing of the books, the profits or losses are divided among the members in proportion to the number of beasts delivered throughout the year. (*Mutatis mutandis* a similar procedure is followed by the other co-operative selling associations, the seller receiving an amount based on periodical quotations at the time of delivery, and a share of the year's profits *pro rata* of his deliveries.)

The co-operative system is also applied in many other directions; indeed, there is practically no aspect of agricultural life in which, in some degree or other, co-operation has not been called upon to play a part. A cement and a machinery factory, electric power stations, various forms of insurance and finally a joint stock bank, with branches throughout the country, may be mentioned. In 1921 this bank had a turnover of Kr. 11,500,000, while the annual turnover of the various co-operative concerns (apart from the bank and the power stations) is estimated at about Kr. 1,500,000,000.

The question of the establishment of a shipping concern by the co-operative producing associations has recently been revived, but no definite decision has as yet been reached in the matter.

BANANA PRODUCTION IN THE EMPIRE.

We have received the following for publication :—

Although many people in the United Kingdom associate the banana particularly with Jamaica and the Canary Islands, not more than two-fifths of the fruit imported into the country comes from those countries, the remaining three-fifths being supplied by Colombia, Costa Rica and the Republic of Honduras.

In 1922, bananas were imported into the United Kingdom to the value of over £5,300,000, of which amount only about £600,000 represented produce of British Possessions. In view of the fact that the banana can be grown in most tropical lands where labour is available, it would therefore seem advisable to consider whether a greater share in the banana industry could not be undertaken within the Empire, more particularly in parts of West Africa which are within a comparatively short distance of the home market. The present position of the industry in the various countries of the Empire is indicated in an article on "The Banana and its Cultivation with special Reference to the Empire," published in the current issue of the *Bulletin of the Imperial Institute*, which also gives particulars of methods of growing the fruit and the preparation of various products, such as banana flour and dried bananas or "figs." Of the British West India Islands, Jamaica is the only important banana producing country, and last year exported (largely to the United States) 12½ million bunches, valued at over £2,250,000, whilst in some years the exports have exceeded 16 million bunches. Trinidad, Barbados and Dominica formerly exported small quantities of fruit but the trade has now almost ceased. British Honduras has an annual output of about half a million bunches, but British Guiana, although producing fruit of excellent flavour, has so far not built up an export trade. In Australia, considerable quantities are grown for local consumption in Queensland and New South Wales, and there is also a large import from Fiji, where banana growing is one of the staple industries. Other parts of the Empire, such as India, Ceylon, Malaya, and East and West Africa, at present only grow the fruit for their own use.

COTTON NOTES.

Through the courtesy of the British Cotton Industry Research Association, the Secretary of the Indian Central Cotton Committee has sent the following abstracts for publication :—

Cotton Cultivation.

A copy of a questionnaire was sent to various cotton growing countries, except the U. S. A. and Egypt, by the International Federation of Master Cotton Spinners' and Manufacturers' Associations. The questions are as to acreage, types grown,

times of sowing and picking, yields, labour, costs, transport, pests, ginning and baling, etc. Replies from 31 areas are given in subsequent pages (*see* following abstracts). [*Int. Cotton Bull.*, 1924, **2,** No. 8. 425-426.]

COTTON CULTIVATION IN BELGIAN CONGO.

Replies to the above questionnaire show that cotton is only grown by natives. The 1923 crop was grown on about 20,000 acres yielding an estimated crop of 1,200 tons, *i.e.*, averaging about 130 lb. per acre (The average size of a native field is about one-seventh of an acre.) For future expansion the area is unlimited but only in the northern districts (Welle) is the labour supply sufficient. Cotton has to be carried on the average a four days march by the natives, followed by 500 miles of inland transport, before leaving the country. [*Int. Cotton Bull.*, 1924, **2,** No. 8, 496-497.]

COTTON CULTIVATION IN CHINA.

Replies to the above questionnaire show that five and a half million acres of cotton are grown in China and a further three-quarters of a million might be added in the next four or five years, if there were strong organizations to lead in extending cotton growing. Expansion is possible only in the northern provinces of Chihli, Honan, Shantung and parts of N. Kiangsu. One-eighth of the total crop in 1922 was American Upland and the remainder the Chinese Annual type. On the average about 200 lb. per acre are produced at a cost of 5·15*d*. a lb. Progress is dependent on demilitarisation within the Empire and on the provision of the necessary funds for research and cotton growing experiment. [*Int. Cotton Bull.*, 1924, **2,** No. 8, 487-489. T. S. KUO.]

COTTON CULTIVATION IN ITALIAN SOMALILAND.

Replies to the above questionnaire describe the efforts which are being made by the Societa Agricola Italo-Somala ("Sais") to introduce cotton growing. Last year 263 hectares were planted, yielding about 370 lb. of lint per acre; the staple was 32-38 mm. [*Int. Cotton Bull.*, 1924, **2,** No. 8, 512-514. SOCIETA AGRICOLA ITALO-SOMALA.]

COTTON CULTIVATION IN PARAGUAY.

Replies to the above questionnaire show that the area under cotton add the yield have expanded enormously since 1920. This year, 13,000 acres are sown and the yield is estimated at 16 million kilos. More than 300,000 sq. km. situated in the eastern and western sections are suitable for cotton growing. Under presedt conditions of population it is expected 65,000 bales of lint per annum may be produced in a few years. Of the actual production, 98 per cent. is of a uniform type selected from Georgia varieties. The average production is from 300 lb. to 500 lb. per acre

of raw cotton that is generally classed as superior to American, and most of the crop goes to Germany and to Spain. [*Int. Cotton Bull.*, 1924, **2,** No. 8, 509-512. GUILLERMO T. BERTONI.]

COTTON CULTIVATION IN SPAIN.

Replies to the above questionnaire show that only about 9,000 acres are under cotton but 5¼ million acres are possibly suitable. The cotton is all of the American type, of which the variety known as Texas reaches 28 mm. in length. No cotton is exported. [*Int. Cotton Bull.*, 1924, **2,** No. 8, 515-516. FRANCISCO DE P. GONZALEZ PALOU.]

COTTON CULTIVATION IN ARGENTINA.

The acreage under cotton has increased from 56,500 in 1922-23 to 154,800 in 1923-24. The Chaco District has 123,550 sown and Corrientes 21,370. Though most of the crop is sold to Germany, Argentine cotton is beginning to find a market in Manchester. [*Int. Cotton Bull.*, 1924, **2,** No. 8, p. 480 ; 1924, **3,** No. 9, 163-166.]

COTTON CULTIVATION IN ASIA MINOR.

The Adana crop fell from 135,000 bales in 1914 to 14,000 in 1916 and 1917 but the 1924 crop is estimated at 160,000 bales. Under the present biennial system of rotation, cotton cultivation in the future may be expected on between two and two and a half million acres each year, indicating a minimum production of 800,000 bales and a maximum of 2,000,000 bales of 500 lb. In order that this result may be achieved improved methods of cultivation, greater financial facilities to cultivators, reform in taxation and improved communications will be essential. Though the American Upland varieties are far more valuable than the native variety, giving a better yield and having a shorter period of growth, the native cottons have undeniable growing advantages under the existing system of cultivation. The bolls of the native varieties remain fixed to the plant even when they are ripe and do not open completely. Consequently the crop can be gathered in one picking and as labour becomes available, and there is no great risk of damage to the lint from rain and dust storms. The fact that the plant retains its boll until all are ripened also offers greater possibilities for the invention of suitable picking machines. As less heat and water are required for the indigenous cotton, the growing of this crop is also possible at higher altitudes than would be possible with the American Upland type. The only difficulty that stands in the way of a rapid extension of Upland cotton, however, is the picking, for it appears to be well suited to the climate of the country. [*Int. Cotton Bull.*, 1924, **2**, No. 8, 481-486. HUSNI SONS and CHINASSI.]

Cotton Cultivation in Korea (Chosen).

The moderate rainfall in summer and sufficient sunshine and dryness in autumn of the Korean climate allows the cultivation of cotton to succeed at a higher altitude than in U. S. A. Only in S. Korea is it possible to grow the American type of cotton, and King's Improved is the variety grown. Statistics as to acreage sown and yields for Upland and native strains are given. Native cotton is mainly used for wadding clothes, cushions and quilts and spun for home-woven cloth. The fibre is harsh, stiff, very strong and pure white in colour. It is poor in yield and lint percentage and is of small value for power spinning. The Upland cotton suits fairly well for power spinning because the staple is longer and more convoluted and it is superior in yield and lint percentage. Its defects are those of bad colour and "weakness in tension, on account of the infancy in farming and some climatic influence." Data on staple lengths, convolutions, breaking load, etc., are given. [*Int. Cotton Bull.*, 1924, **2,** No. 8, 500-508. S. Kamisaka.]

Cotton Cultivation in S. Africa.

The yield of the 1922-23 crop was approximately 4,800 bales (of 500 lb.). In staple length, 25 per cent. was $1\frac{3}{16}$ in. and over; 43 per cent. was $1\frac{1}{8}$ in.; and 32 per cent., 1 in. and under. In grade, 65 per cent. of the crop was better than Fully Middling, $14\frac{1}{2}$ per cent. was graded Middling and below, while $20\frac{1}{2}$ per cent was off colour. The available lands for future development, where soil and climate are favourable, comprise generally the whole of the middle and low veld areas; and of those possibly four million acres are suitable for cotton growing. Inefficiency of labour is one of the outstanding problems; but the supply is sufficient, if carefully trained, to build up a production of 500,000 bales in comparatively few years. The cost of production is roughly estimated at £1 per acre and the profit per acre. for an average crop of 600 lb. seed cotton at present prices, is £8. [*Cotton News Weekly*, 1924, **1,** No. 11, 262-264. W. H. Scherffius.]

Effect of density of Cotton Bale on yarn strength.

The effects of baling cotton at different densities, on the strength of the yarn produced, were found to be:—(1) high density compression of cotton, in a dry condition, does not injure its spinning value; (2) the waste of wet cotton compressed to high density is increased, and the breaking strength of the yarn is reduced; (3) round baling with a hard core results in a reduction of the yarn strength about 7 per cent. Pure strains of Cleveland Big Boll, Rowden, Delta and Webber 49 were used in these tests. [*U. S. Dept. Agri. Bull.* No. 1135, May 1923. W. R. Meadows and W. G. Blair.]

Cotton Cultivation in Russia (Turkestan).

The area under cotton in 1923 amounted to about 405,000 acres and, for the current season, efforts were to be made to double the acreage. The 1923 crop yields for Turkestan and neighbouring districts were in bales of 500 lb.:—Turkestan, 190,000; Bokhara, 38,000; Khiva, 11,000; and N. W. Persia, 23,000. This production represented about five-eighths of the raw cotton requirements of the Russian manufacturing industry. [*Int. Cotton Bull.*, 1924, **3**, No. 9, 171-176.]

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

THE designations of —

(1) The Imperial Bacteriological Laboratory, Muktesar,
(2) Director and First Bacteriologist, Muktesar Laboratory,
(3) Second Bacteriologist,
(4) Third Bacteriologist,
(5) Veterinary Officer

are changed to

(1) The Imperial Institute of Veterinary Research, Muktesar,
(2) Director, Imperial Institute of Veterinary Research,
(3) First Veterinary Research Officer,
(4) Second Veterinary Research Officer,
(5) Third Veterinary Research Officer,

respectively.

DR. W. MCRAE, Officiating Imperial Mycologist, Pusa has been granted leave on average pay for six months from 11th April, 1925. Mr. M. Mitra, M.Sc., First Assistant, will hold charge of the current duties of the office of Imperial Mycologist in addition to his own.

THE Elliott Prize (Gold Medal and cash) for Scientific Research, for the year 1923, was awarded by the Asiatic Society of Bengal to Mr. Bhailal M. Amin, B.A., Assistant to the Imperial Agricultural Chemist, Pusa.

THE title of Khan Bahadur has been conferred upon Mr. Gul Muhammad Abdur Rahaman, Divisional Superintendent of Agriculture, Sind.

MR. W. GREGSON, N.D.A., Deputy Director of Agriculture, has been placed in charge of the Northern Circle, Burma, *vice* Mr. L. Lord proceeding on leave.

REVIEWS

Practical Bacteriology: An Introductory Course for Students of Agriculture.—By A. Cunningham. Pp. viii+188. (London and Edinburgh: Oliver and Boyd.) Price, 7*s.* 6*d.*

This book presents in a highly condensed form a series of laboratory exercises in bacteriological technique for agricultural students. In lecturing on such a subject for examination purposes it is necessary to take into account the lamentable fact that the biology of soils, although fully recognized as of prime importance in connection with the study of the subject of fertility, holds as yet a comparatively unimportant place in agricultural curricula. Hence we find in such a book as this the section (Chapter IV) devoted to bacteriology of soil (and of farmyard manure) occupying some twenty pages out of a total of one hundred and eighty, whereas the previous one (Chapter III) dealing with milk and milk products absorbs thirty-five pages. It is impossible to criticize the author on these grounds; he has to work to a lecture syllabus for examination purposes and to deal with large classes requiring correspondingly extensive supplies of apparatus and bench and incubator space. Hence it is necessary to restrict laboratory experiments accordingly, and this is most readily done by devoting attention to such lines of work as allow of qualitative rather than quantitative demonstration. The bacteriology of soil, depending as it does upon quantitative measurements rather than upon qualitative investigation, naturally suffers in a lecture course when brought into competition with the more obvious reactions of the dairy bacteriologist, but the responsibility for such neglect rests not upon the lecturer but upon those authorities whose examination policy places the bacteriology of soil in such a subordinate position that funds are not forthcoming for its proper treatment as the most important method of dealing with the fundamental problem of soil fertility. When due recognition is accorded to this subject by our universities it will be possible to arrange for its fuller study even by large classes of students; such study will then allow of its treatment as a separate subject, complete in itself, and it will no longer be considered necessary to include in lecture courses and text books dealing with it such extraneous studies as those concerned with dairying and the diseases of plants and animals. The author has presented in the present volume a very well written and up-to-date compendium of exercises which should be of great value to lecturers and students; particularly noticeable is the large amount of useful technical information which has been brought into such a comparatively small compass. [C. M. H.]

Bhuler Fasal (in Bengali).—By D. N. Mitra, District Agricultural Officer, Faridpur. Pp. 79. (Kantik Press, Calcutta.) Price, As. 10.

This little book written in popular Bengali is a commendable attempt on the part of an officer of the Bengal Department of Agriculture to make known its numerous activities in the form of four fascinating stories. Its perusal will dispel many doubts about the soundness of the propaganda work carried on by the department. The problem of unemployment is indirectly touched upon and the dignity of labour has been emphasized. The author finds little difficulty in demonstrating that agriculture conducted on scientific lines is a remunerative industry and can be pursued with profit by many men of the *bhadralok* class for whom the struggle for existence has become keener than ever. As observed by Sir P. C. Ray in the preface, the author has adopted the right method of arous'ng enthusiasm for improved methods of agriculture.

NEW BOOKS

On Agriculture and Allied Subjects

1. Crop-production in India, by Albert Howard, C.I.E. (Oxford University Press.) Price, 10*s*. 6*d*.
2. Oats: Their Varieties and Characteristics. A Practical Handbook for Farmers, Seedsmen and Students. Pp. 131. (London: Ernest Benn & Co.) Price, 8*s*. 6*d*.
3. Crops and Fruits, by J. R. A. Davis. The Resources of the Empire Series. Pp. 144. (London: Ernest Benn & Co.) Price 21*s*.
4. Manures and Fertilizers, by W. Dyke. Edited by T. W. Sanders. Pp. 142. (London: Collingridge & Co.) Price, 4*s*.
5. Chemistry in the Twentieth Century. An account of the Achievement and the Present State of Knowledge in Chemical Science. Prepared under the guidance of a committee representing the scientific societies, with Dr. E. F. Armstrong, F.R.S., as Chairman and Editor. Pp. 281. (London: Benn Bros.) Price, 15*s*.
6. The Punjab Peasant in Prosperity and Debt, by M. L. Darling, I.C.S. (Oxford University Press.) Price, Rs 9.

THE following publications have been issued by the Imperial Department of Agriculture in India since our last issue:—

Memoirs

1. Studies in Diseases of the Jute Plant. (2) *Macrophoma Corchori* Saw., by F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S. (Botanical Series, Vol. XIII, No. 6.) Price, As. 8 or 9*d*.
2. Buffer Action of Some Burma Soils, by J. Charlton, M.Sc. (Chemical Series, Vol. VII, No. 5.) Price, As. 12 or 1*s*.
3. Studies in the Chemistry of Sugarcane, II. Some Factors that determine the Ripeness of Sugarcane, by B. Viswanath, F.I.C., and S. Kashinatha Ayyar, B.A. (Chemical Series, Vol. VII, No. 6.) Price, As. 8 or 9*d*.

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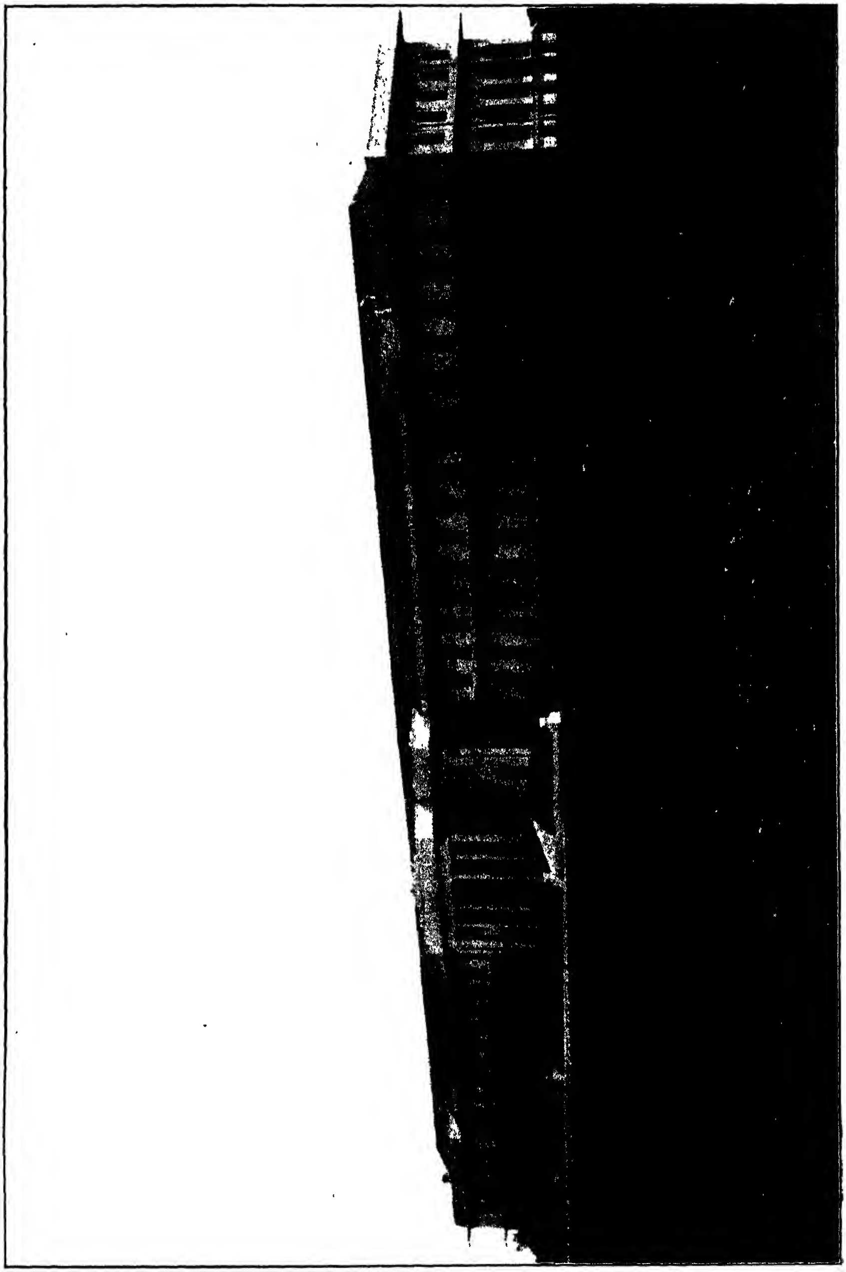
R. S. Gondhalekar's Book Depôt, Publisher and Bookseller, Budhwar Chawk, Poona City.
Managing Director, Co-operative Bookstall, Booksellers and Publishers, Poona City.
The Standard Bookstall, Karachi, Rawalpindi, Murree, Lahore, Peshawar and Quetta.
Karsandas Narandas & Sons, Surat.
A. H. Wheeler & Co., Allahabad, Calcutta and Bombay.
N. B. Mathur, Supdt., Nazir Kanun Hind Press, Allahabad.
The North India Christian Tract and Book Society, 18, Clive Road, Allahabad.
Ram Dayal Agarwala, 184, Katra, Allahabad.
Manager, Newal Kishore Press, Lucknow.
The Upper India Publishing House, Ltd., 41, Aminabad Park, Lucknow.
Munshi Seeta Ram, Managing Proprietor, Indian Army Book Depôt, Juhi, Cawnpore.
Rai Sahib M. Gulab Singh & Sons, Mufid-i-Am Press, Lahore and Allahabad.
Rama Krishna & Sons, Booksellers, Anarkali Lahore.
Puri Brothers, Booksellers and Publishers, Katcheri Road, Lahore.
Manager of the Imperial Book Depôt, 63, Chandney Chawk Street, Delhi.
Oxford Book and Stationery Company, Delhi.
Supdt., American Baptist Mission Press, Rangoon.
Proprietor, Rangoon Times Press, Rangoon.
The Modern Publishing House, Ltd., 30, Phayre Street, Rangoon.
The International Buddhist Book Depôt, Post Box No. 971, Rangoon.
Manager, the "Hitavada," Nagpur.
S. C. Talukdar, Proprietor, Students & Co., Cooch Behar.
Times of Ceylon Co., Ltd.
The Manager, Ceylon Observer, Colombo.
The Manager, The Indian Book Shop, Benares City.
B. C. Basak, Esq., Proprietor, Albert Library, Dacca.

PLATE IX.



THE BURMA AGRICULTURAL COLLEGE AND RESEARCH INSTITUTE, MANDALAY.

ORIGINAL ARTICLES

THE BURMA AGRICULTURAL COLLEGE AND RESEARCH INSTITUTE, MANDALAY.

The Burma Agricultural College and Research Institute, Mandalay, was officially opened by His Excellency the Governor of Burma, Sir Spencer Harcourt Butler, G.C.I.E., K.C.S.I., I.C.S., in the presence of a large and distinguished gathering on the afternoon of 22nd December, 1924.

Accommodation for the guests was provided in a semi-circular arrangement of seats in front of the main steps of the building and facing the main entrance door, while His Excellency and the platform party had seats on the portico above the main steps. His Excellency on arrival was met by the Hon'ble U Pu, Minister of Agriculture, Mr. MacKenna, Development Commissioner, Mr. McKerral, Director of Agriculture, Mr. Charlton, Principal, and all the principal local officials of Mandalay. A guard of honour consisting of 100 men of the 1/20th Burma Rifles was provided under the command of Captain Ward-Simpson. After the inspection of the guard of honour and when His Excellency had taken his seat on the platform, the Minister of Agriculture addressed the assembly.

Speech of the Minister of Agriculture.

The Hon'ble U Pu, Minister of Agriculture, who spoke in Burmese, gave a short history of the Agricultural College, pointing out that this history dates back to 1906, the year in which a separate Department of Agriculture was formed in Burma. In that year the creation of a separate appointment of Director of Agriculture was sanctioned by His Majesty's Secretary of State, and on 15th October, 1906, Mr. MacKenna assumed charge of the Agricultural Department. It was the intention of the Government to establish an Agricultural College at a very early date, and Mr. E. Thompstone who was appointed Principal in May 1907 took up the work of planning the College and arranging a scheme of studies. Owing, however, to financial reasons and other causes, it was not found possible at that time to proceed with the erection of the building. Later the War supervened when all expenditure had to be curtailed to the utmost, and as a result the matter was kept in abeyance till the arrival of His Honour Sir Reginald Craddock as Lieutenant-Governor of Burma in 1917. One of the first acts of Sir Reginald's administration was to cause a complete reorganization scheme for the Agricultural Department to be put in hand. During the interval, however, the Agricultural Department was not idle. Central experimental farms were opened at Hmawbi and Mandalay and smaller farms at

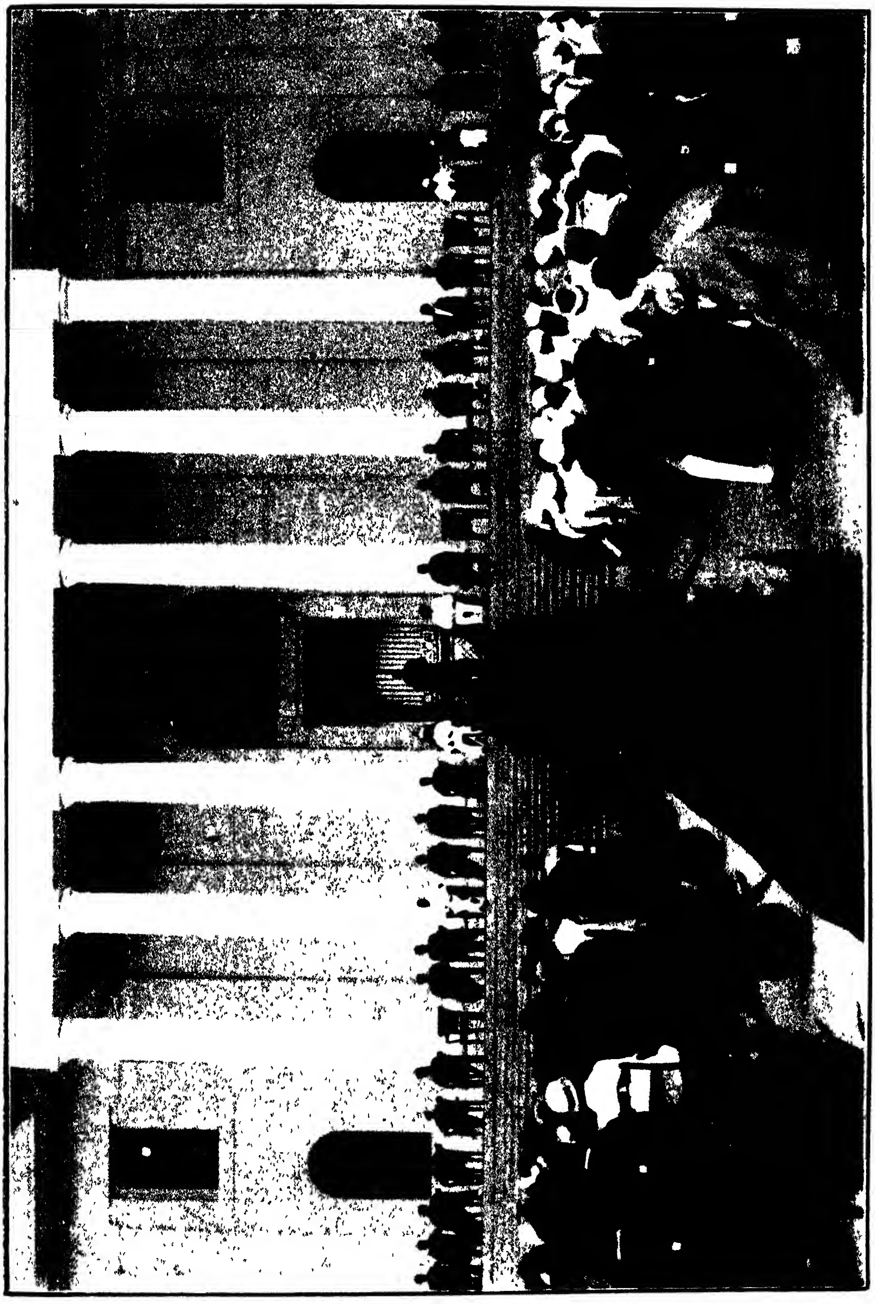
various other places. Extensive investigations were made into the possibility of improvement of most of the important crops of the province and some very definite results have been obtained. The Hon'ble Minister proceeded to give an extensive account of these results. In the meantime the need for staff became very pressing, and the Government of Burma had to throw itself on the hospitality of the Government of Bombay and to send a certain number of students for training to the Poona Agricultural College. Up to date no fewer than 19 students from Burma had graduated at Poona and returned to work in the Agricultural Department of Burma. The latter was under a great debt of gratitude to the Government of Bombay and the officers of the Bombay Agricultural Department for the hospitality they have extended and for the great interest they have taken in the training of these students from Burma. The Hon'ble Minister proceeded to remark, however, that this policy must be a makeshift one only, and that a great province like Burma could not and should not depend on the good will of other provinces for the training of its agricultural staff.

He proceeded to ask "what are the principal functions of an institution like the Agricultural College of Burma" and to divide them into two main heads (*a*) Research and (*b*) Teaching. In connection with research, he remarked that in Burma they could not aspire to the gigantic activities of a great Agricultural Department such as exists in the United States of America, but that they could in a humbler way imitate their methods and endeavour to achieve in some measure at least their results. In connection with the second aspect of the work, he remarked that primarily the teaching side of the work at the Agricultural College will be to provide the necessary staff for the Agricultural Department proper, but that in addition to this department, the Burma Civil Service, the Co-operative Department, the Land Records Department and perhaps the Irrigation Department are also departments which are in close touch with the cultivating classes and which would be benefited by having on their staff a certain proportion of men who had received a good all-round training at this College. He also expressed the hope that in the near future the College would be affiliated to the Rangoon University, a degree of B.Sc. in Agriculture instituted and this degree or the diploma awarded by the College recognized as a qualification for appointment to the services above-mentioned. The Hon'ble Minister also expressed the hope that as agricultural education progresses and as new methods are discovered, there will be an increasing desire on the part of the larger landowners to send their sons for a course at the College with a view to the improvement of their own estates.

His Excellency's Speech.

His Excellency then addressed the assembly as follows :—"U Pu, Mr. MacKenna and Gentlemen—I have come to-day to declare the Agricultural College open. Rome was not built in a day, nor was this College, but it has struggled through what

PLATE X.



H. E. SIR HARCOURT BUTLER ADDRESSING THE ASSEMBLY.

I may call the contraceptional influences of public indifference and departmental delay and is now about to commence its career of utility.

"The building which we owe to the skill and taste of Mr. Foster is a fine one. The foundation-stone was laid by my distinguished predecessor Sir Reginald Craddock. The College will meet a great want in the province and this is a red letter day in the agricultural history of Burma.

"The Hon'ble Minister has reviewed the work of the College, its aims, objects and ideals. A Committee as you know is sitting to consider the whole question as to how agriculture can best be stimulated in Burma. I do not wish to anticipate the findings of that Committee, but it is clear that the work of the College will be teaching and research.

"In my Convocation speech the other day I emphasized the importance of research, and in no branch of scientific discovery is this more important than in agriculture. The value of any important discovery is so far-reaching that it is worth spending large sums for five, ten and even twenty years in accumulating the results of experiment and inquiry, in testing knowledge with a view to discovering some new processes, some antidote, some economy of effort or resources.

"Research in agriculture is insurance against the future. Without it the science of agriculture will stand still and the teaching of agriculture will have little meaning. For research you want good libraries, good laboratories, and leisure for the Professors, and I hope that those who ultimately control this College will realize the necessity of these three ingredients of original work. We owe a debt of gratitude to Sir Reginald Craddock, to Mr. Justice J. A. Maung Gyi, to Mr. MacKenna, to Mr. McKerral and to Messrs Dove, Scovell, Whitcombe and Duncan, the Engineers who had most to do with the building, and to Mr. Foster, the Architect, for all the trouble that they have taken, and I now have great pleasure in declaring this building open."

On the conclusion of His Excellency's speech, Mr. T. O. Foster, F.R.I.B.A., the Architect of the building, presented His Excellency with a gold key with which His Excellency opened the door of the building.

His Excellency was then conducted over the College by Mr. Charlton, the Principal, and made a complete inspection of all the class rooms and the laboratories. The building was also thrown open for inspection by the guests.

The College Buildings.

The main College, which has a frontage of 480 feet, is sited on an axial line $2\frac{1}{2}$ miles due south from the Mingala Gate, Fort Dufferin. In order to obtain this fine position, the Architect was successful in getting the Public Works Department to realign a part of the Canal and straighten out about half a mile of roadway.

The building is three storied, *viz.*, semi-basement floor, ground floor and first floor. It has unobstructed North lighting throughout, verandahs being provided on the south, east and west only.

The central feature is a large museum hall marked by a portico; it originally had a dome to hold the interest of the long vista but on the score of economy this was abandoned. and the Architect designed very large iron and glass doors which rivet the interest to the centre in a very happy way. The main staircases are situated in apses on either side at the south end of the main half and are of interest, in that they are constructed on the cantilever principle, the lines of the curves being enhanced by the handling of the balcony corridor on which they culminate. Subsidiary staircases are placed at the east and west ends.

The semi-basement is devoted to the Mycological and Physics Laboratories, also the Examination Hall and stairs, while on the ground floor the administrative offices lead off from the main hall and on the east and west of the same are situated the Botanical and Entomological Laboratories respectively. The Chemical Laboratories are placed on the east wing of the first floor, while the west wing contains lecture rooms and laboratories for Agriculture, Engineering and Veterinary Science, also the Library and Reading Rooms.

In the College itself, 57 per cent. of the space provided is devoted solely to research work.

The building is constructed of brick and plaster, the floors being reinforced concrete. The windows are Messrs. Crittals' steel frames. The laboratories are equipped with gas and water on modern European standards and the building is electrically lit throughout.

The Hostel provides for 84 students spread over a course of four years.

There are also houses for the staff and subsidiary outbuildings.

The Farm and College Estate.

The College Farm extends to slightly over 600 acres of land practically all irrigable from the Patheingyi Distributary of the Mandalay Canal. The soil of the farm is of a stiff clay consistency and is typical of the Mandalay Canal area. It grows good paddy under irrigation and can be made to produce most of the cultivated crops of the province.

Part of the farm was intended to be used for the College Dairy and milking herd but the dairy scheme has been abandoned for the present, and it is intended that this area should be utilized for the building up of a pedigree herd of pure Burmese cattle. There will thus be facilities provided to students for instruction in the handling, feeding and breeding of stock.

Six tennis courts have been provided for the students, and there will be ample facilities for football and hockey as well.

The Library and Reading Room.

The reading room is situated on the basement floor, and accommodation for the book cases of the library has been provided on a balcony above this on the ground

floor. The book cases for the library were designed by Mr. H. Cooper Anderson, F.R.I.B.A., and have been made in Mandalay by Burmese craftsmen. It is expected to spend up to Rs. 50,000 on the provision of books for the library which will be open to the students of the College and also to passed students and certain members of the outside public interested in agricultural matters.

THE COURSE OF INSTRUCTION.

It has been decided to have one course of instruction only and in the meantime this will extend over four years.

It is expected that the College will be affiliated to the Rangoon University at an early date and the course of instruction has been drawn up to suit University requirements and in accordance with University standards. For the present the standard of entrance is the High School Final Class A., *i.e.*, the same as for the entrance to the University. This entails on the College staff a certain amount of teaching in English and Elementary Physics and Chemistry, and it is hoped that it will be possible in the early future to raise the standard of entrance to that of the University I.A. or I.Sc., and to substitute a three years for the present four years course. During the first two years and leading up to the Intermediate examination the students will study the following subjects :— English, Mathematics and Physics, Botany, Chemistry, Agriculture (including Veterinary Hygiene) and Plant Pests and Diseases. During the second two years and leading up to the final diploma or degree examination, the subjects will be Agriculture (including Agricultural Economics), Botany (including Agricultural Botany and Plant Breeding), Chemistry (including Agricultural Chemistry), and Surveying and Agricultural Engineering.

DEVELOPMENT OF AGRICULTURE IN INDIA.*

BY

R. S. FINLOW, B.Sc., F.I.C.,

Director of Agriculture, Bengal.

The choice of a suitable subject for an address to this Section is becoming an increasingly difficult matter, for I find that my predecessors have dealt with practically every phase of the agricultural problem in India. I was tempted on this account to follow the example of my immediate predecessor and deal with what I may call my own special subject of fibres. This, however, would have required lengthy treatment, which did not seem to be desirable on account of the long programme of papers submitted by members. Therefore, though I know that some repetition is inevitable, I decided to confine myself to a short review of work which has been done, and of the progress which is being made in the improvement of Indian agriculture.

It is well known that many attempts at agricultural improvement in India were made long before the inauguration of the Indian Agricultural Service, and that the record of such attempts goes back beyond the middle of the nineteenth century. There seem to have been periodical impulses towards agricultural progress, but, while nearly all these took the form of organization and propaganda, none culminated in the prosecution of research. The result was that whatever enthusiasm was generated soon died, because there was no one to point the way and to show what was to be done. It was not realized at that time that research and then demonstration must precede propaganda, and in India the general recognition of this as a principle is probably not much older than the present century.

The position at this time is well described by His Excellency Lord Ronaldshay, late Governor of Bengal :—

" This energy exerted itself mainly in attempts to organize the public interested. It was not based on research, nor had any research been done, and the actual results achieved, so far as the advancement of the industry is concerned, were practically nil. The period was productive, however, of one valuable lesson, namely, that there is nothing to be gained by organizing the public unless there is something for the public, when organized, to do. In other words, that experiment precedes demonstration and that research is essential before any advancement can be made through propaganda. This having at last been realized, a rational policy, namely, that of

* Presidential Address at the Agricultural Section of the Indian Science Congress, Benares, 1925.

promoting research, and then giving wide publicity to the conclusions to be drawn from the experiments made, was adopted, and Lord Curzon's Government established the Indian Agricultural Service in 1904-05, and proceeded to recruit to it specialists trained in all branches of agricultural science."

The failure of the old attempts at agricultural improvement was of course used by many to support the argument that "the cultivator knows his own business best." This attitude was also commonly taken up in regard to the Department of Agriculture after its formation. The critics looked for immediate results, of course, and Lord Ronaldshay again describes the situation :—

"I doubt if any department of Government has been the subject of more uninstructed criticism than has the Department of Agriculture. Its earlier years were necessarily devoted to research, with the result that the public saw little of the activities of the new service ; and the pessimists among the critics began to shake their heads in gloomy satisfaction at what they regarded as the failure of experts and the vindication of their own dismal lucubrations. The cultivator himself, however, is not slow to recognize a good thing when he sees it, and about the year 1910 the first fruits of the experiments of the scientists began to come to his notice. When he realized that, as a result of these experiments, greatly improved races of his staple crops were forthcoming, he did not fail to take advantage of them, with the result that, to-day, pure line cultures, as they are called, of many of the principal Indian crops are being grown literally on millions of acres throughout the continent."

Thus, the splendid work of the plant breeder has received abundant recognition from the cultivator, who is a good judge ; but large as is the present area under improved crops, it is only a small proportion of the whole cultivated area. Much yet remains to be done, and the time is therefore far distant when the task of the plant breeder could be considered to be even approaching completion.

The work of the Agricultural Department embraces practically every phase of farming ; but the cultivation of improved crops is as yet the only departmental recommendation which can be said to have been applied on a really large scale by the cultivator.

This is not because other valuable recommendations have not been made. For instance, in Bengal, the application of bonemeal as a manure for transplanted paddy on red soils and the use of lime and potash for jute on highlands have been shown to be at least as profitable as the cultivation of improved crops. They have also been widely demonstrated, but there is comparatively little permanent demand. What is the reason ? The use of improved seed involves little or no greater expenditure than the cultivator is in the habit of making, whereas the application of artificial manures, or the purchase of an implement, means the spending of ready money. In Bengal and also in other large tracts in India, there are not many ryots who can afford to do this. Thus, in the solution of the agricultural problem in India, progress beyond the evolution and distribution of improved seed involves the control of a

financial factor not hitherto of importance. In other words, it is at present often necessary, not only to convince the cultivator of the desirability of an improvement requiring an initial outlay of money, but also, when this has been done, to advance the necessary sum to enable him to put the improvement into practice. When we consider the size of India, the millions of cultivators concerned, and the magnitude of the financial operations involved in anything like a wholesale purchase of manures or implements, it is not a matter for great surprise that the increased use of manures and better implements has not made the rapid progress attained by cultivation of improved crops.

But whether the financing agency will be from Government direct, through executive officials in the districts, or through co-operative banks, or through savings banks, or thrift societies, it is plain that India cannot achieve a large proportion of the economic improvement which is possible to her, until this problem is solved.

Even the cultivation of improved crops implies the necessity of improved agricultural practice. This has been pointed out by Mr. Milligan and Dr. Leslie Coleman in his presidential address to this Section ; and doubtless by others including myself. Normally, though of course not necessarily, a crop which gives a higher yield takes more plant food from the soil than a lesser yielder. Therefore, if the cultivation of high yielding strains be not accompanied by better farming in other directions, the maximum benefit from the high yielding strains may not only be attained, but there may also be danger of further exhaustion of the soil. Apart from this, however, the ultimate possibilities of increase, as a result of proper manuring, good tillage, and good agricultural practice generally, are considerably greater than those which could be expected from crop selection alone. Examples in illustration are doubtless familiar to all of us, and there can be no two opinions as to the advisability of substantial progress in this direction at the earliest possible moment.

Another aspect of the necessity for proper treatment of the soil is the danger of disease. There is now a good deal of evidence that the incidence of certain fungus diseases is connected with soil conditions. For instance, *Rhizoctonia* in jute seems to be definitely connected with lack of available potash, while the attack of *Diplodia corchori* on jute appears to be inhibited by application of sodium sulphate. On the other hand, phosphates appear to encourage the appearance of *Fusarium udum* in *rahar* (*Cajanus indicus*), while green manure hinders the onset of the disease.

Not only fungus, but insect attacks appear to be connected, at least in some cases, with malnutrition. In the course of manurial experiments with potash on jute on the red soil at Dacca, it was definitely noticed that non-potash plots were much more liable to attack from a small white sucking insect (*Aleurodidæ*) than plots which had received potash salts. In this case the plots which had received carbonate of potash were most free from attack. But the most striking example of a connection between insect disease and soil conditions is the report from the Indian Tea Association Research Station at Tocklai, Assam, that mosquito blight (*Helopeltis theivora*) may be cured by direct inoculation of the tea bush with potash

salts. The Review of Agricultural Operations in India for 1919-20 says :—" Bushes which had apparently succumbed entirely to the attack of the pest were cured through inoculation and gave vigorous flushes, although the surrounding untreated bushes remained in a moribund state." I have no doubt that many entomologists and others will remember the enthusiasm of the late Mr. Howlett, Imperial Pathological Entomologist, in investigating chemical substances, the smell of which would attract or repel insects. In some cases sex relations seemed to be involved, and it is possible that the observations on the insect pests referred to above may have a similar explanation. In the latter case, however, suitable nutrition for the insect, or the reverse, would appear to afford an equally satisfactory reason.

An increasing amount of work is being done in this direction, and its importance is indicated by the fact that it forms the subject of a special open debate at this Congress. Collaboration between chemists and physiologists with botanists, entomologists and agriculturists is called for, and I need hardly point out how fruitful the field for investigation promises to be.

It is well-known to all of us that jungle, and bad cultivation, encourage pests. An interesting instance of this is the mango weevil, which does great damage to mangoes in Eastern Bengal. It is worthy of note that this pest only appears to be a serious menace to mangoes east of the Brahmaputra in Bengal. In any case it has been established that good cultivation of the soil of the mango grove, especially near the stems of the tree, is a very effective remedial measure.

It is not to be concluded from what I have said above that my proposals for the elimination of plant disease are confined to manuring. It is probable, as I have shown above, that in some cases special manuring may be essential but other great factors must never be forgotten, *e.g.*, tillage, drainage, etc. Good cultivation will certainly render available to the plant stores of food in the soil which it could not otherwise touch, thus saving, at least to some extent, the great expense of manuring. Again, drainage and its results undoubtedly have influence in regard to incidence of plant disease. Thus the problem is a complex one and its importance demands all necessary attention for its solution.

We then come to the conclusion that, while the evolution and the raising, on an increased scale, of improved varieties of crops, should be encouraged in every way, good cultivation and good manuring, in fact everything which constitutes good agricultural practice, is a goal towards which all interested in agriculture in India should steadfastly press forward. It is not only that the resulting crops will be bigger ; but that being healthy, they will be more capable of resisting disease, and thus less subject to that toll of loss, which is by no means negligible, and which means so much less food for the teeming millions in this great country. I quote in conclusion an apposite paragraph from the Review of Agricultural Operations in India, 1922-23 :—" The very success of the plant-breeding operations has, however, overshadowed other and no less important factors in crop production, such as

cultural methods and the maintenance of the fertility of the soil. A knowledge of the relations between soils and plants, under the varying conditions of the country, is essential for a proper understanding of the agricultural situation, and the development of this side of agricultural work in India is of first rate importance. Land improvement will no doubt be a matter of slower growth than crop improvement, as capital, or at least credit, will have to be forthcoming for its fulfilment, but there is ample evidence in more than one province that co-operative effort will remove most, if not all, of the difficulties which are likely to be encountered."

The Department of Agriculture in India has, through the results of its work, already shown itself to be one of the soundest investments the people of India could make. But the possibilities are far greater than the achievements to date, and we may pray for their speedy realization. Agriculture must always be the main fountain of Indian wealth, and from a substantial increase in the wealth of the individual cultivator a corresponding increase in the resources of the State as a whole is achieved. It is only in this way that all the laudable schemes for education, sanitation, and general social upliftment can advance to fruition.

PLATE XI.

Mr. GEOFFREY EVANS, C.I.E., M.A.

Mr. GEOFFREY EVANS, C.I.E., M.A.

AN APPRECIATION.

Mr. G. Evans, C.I.E., M.A. (Cantab.), Director of Agriculture, Bengal, who went on leave over two years ago, has retired from the Indian Agricultural Service on proportionate pension.

Mr. Evans is a graduate of Cambridge University, having taken the Natural Science Tripos with Honours. He also took the Diploma in Agriculture and was Assistant Professor of Agriculture in the Cambridge University, Department of Agriculture, at the time he accepted an appointment in the Indian Agricultural Service. He landed in India on 22nd October, 1906, and was made Principal of the Agricultural College at Nagpur at the early age of twenty-three. In November 1907, he was transferred to the administrative branch of the Agricultural Service as Second Deputy Director of Agriculture at Hoshangabad. He was confirmed as Deputy Director of Agriculture, Northern Circle, in 1909, and his headquarters were transferred to Jubbulpore in 1912. Wheat and cotton are the two main staples of the Central Provinces, and it was on these crops that most of his work was concentrated.

Mr. Evans was permitted to join the Indian Army Reserve of Officers in 1917, and for some months he worked in the Adjutant-General's branch as a temporary Captain, being Recruiting Officer for the Northern area of the Central Provinces, where his long service and intimate knowledge of the people rendered him very successful in securing recruits for the army.

In 1918 and 1919 he saw service in Mesopotamia, being placed on the staff of the Quartermaster-General of the Mesopotamia Expeditionary Force, and was entrusted with the task of ensuring the food supply of the force as regards cereals, fodder and dairy produce, which had been severely endangered by German submarine activities. The personnel of the Military Farms Department in Mesopotamia was also placed under his command. By the end of the war he had been promoted to the rank of Colonel. In addition to being mentioned in Despatches he was honoured with a Companionship of the Order of the Indian Empire by H. M. the King Emperor for services rendered in this campaign. He was finally gazetted out of the service with the permanent rank of Lt.-Colonel. Towards the end of the war he was instrumental, in collaboration with Captain R. Thomas, in initiating a series of experiments with long staple cotton in Mesopotamia, the results of which are likely to prove of great importance in the future.

On return from war service he rejoined the agricultural staff of the Central Provinces on 19th May, 1919, but immediately afterwards his services were requisitioned by the Government of Burma for a short period with a view to advising

in the re-organization and future development of the Agricultural Department in that province. On 5th July, 1920, he joined his appointment as Director of Agriculture, Bengal, and in addition held charge of the Department of Fisheries.

During his tenure of the Directorate of Agriculture in Bengal, Mr. Evans displayed his appreciation of local agricultural problems by organizing means of bringing the discoveries of the research section at Dacca into the ordinary agricultural practice of the countryside. The organization and establishment of seed stores, of new demonstration and seed farms and the formation of Agricultural Associations on co-operative lines amongst real agriculturists, are a few instances of the many-sided development carried on by him.

Apart from his organizing capacity, Mr. Evans is possessed of a personal magnetism attractive even to those who would be his opponents. The key-note of his character is a kind-hearted generosity which, with inborn courtesy and frankness, has endeared him to all who came into contact with him. This is particularly true in regard to his relations with his official subordinates.

Mr. Evans left India at the age of 39. He was one of the original band of enthusiasts who laid, firm and strong, the foundations of the Agricultural Department in India. Their devoted work has produced wonderful results in the short space of 20 years, and their loss to India is irreparable.

From India, after a short period spent in England, Mr. Evans proceeded to Australia as an officer of the British Empire Cotton Growing Corporation. Recent news of his achievements show that he has applied his great qualities to his new work, in which we confidently wish him all success for the future.

R. S. Finlow.

SUGARCANE BREEDING IN INDIA—HYBRIDIZATION TO TESTING.

BY

RAO SAHEB T. S. VENKATRAMAN, B.A.,

Government Sugarcane Expert, Coimbatore.

I. INTRODUCTION.

LEAVING out of account, for the time, sporadic, often unauthenticated and generally unsuccessful attempts at growing sugarcane from seed, the first success in this direction in India was achieved in the year 1911 by Dr. C. A. Barber, C.I.E.[1]

This led to the foundation at Coimbatore of a Sugarcane-breeding Station for the whole of India with the definite object of evolving improved varieties through breeding. The poor quality of the canes grown in the country—some of them the poorest specimens of cane in the whole world—is one of the chief reasons for the very low acre yields obtaining in India. The low yields render it necessary for India to import from outside, annually, sugar valued in most years at over fifteen crores of rupees or ten million sterling, in spite of her possessing within her own confines nearly half the world area under sugarcane.

In view of the increasing attention that, in recent years, is rightly being given to the breeding of sugarcanes in various parts of the world, it is thought, it might be of some use to sketch briefly in this note certain details of the technique as adopted at the Coimbatore station. This increased attention is not a little due to the outbreak in certain localities of new, little understood and serious diseases of the cane crop. Certain noticed differences between the Indian work and that done elsewhere, together with the apprehension that the Indian work is but little known outside, as judged from references in published papers, have been additional inducements for writing this note.

II. NEED FOR CAREFUL STUDY OF PARENTS.

While the wide diversity of forms from a variety, even when self-pollinated, is easily the first observation that strikes a sugarcane breeder as he starts his work, a certain similarity in the seedlings obtained from the same parent soon forces itself on his attention as the work extends. The indigenous Indian canes are of a type quite distinct from the tropical kinds, and striking differences between the seedlings

[1] Barber, C. A. Seedling canes in India. *Agri. Jour. India,* Vol. VII, Pt. 4, p. 317.

raised from each class soon revealed themselves. Subtle but none the less appreciable differences were found to separate batches of seedlings obtained from even allied parents.

It was found that the quickest results for India were obtainable from raising seedlings after a definite cross-pollination. This has proved so fruitful of practical results that, in recent years, all the lakh or lakh and a half of seedlings raised each year have been the result of definite and often complicated cross-pollinations. The use of the wild *Saccharums* as parents was found particularly suitable for producing types for cultivation in sub-tropical India with its rather unfavourable conditions for sugarcane growing.

For designing cross-pollination operations one of the first essentials is a knowledge of the type of seedlings each parent gives rise to. Consequently, every variety that happened to flower had its arrows collected—if possible after selfing—seeds sown and the characteristics of the resultant population recorded. The data, so far collected, though far from being accurate for drawing definite conclusions as to the inheritance of characters in the sugarcane, are of considerable practical use in designing the crossings. Inherent difficulties in the work have so far prevented the elucidation of any laws in the matter of inheritance.

It has been found, for instance, that vigour and hardiness could be induced in a population by crossing with *Saccharum spontaneum*, that such crossing appreciably lowers the sucrose and purity in juice, that short but erect seedlings are obtained from mating with Mauritius seedling 1237, that increase in sugar contents could be secured by using Barbados 208, Vellai, B. 3412, P. O. J. 100 or Co. 214 as one of the parents, that one should be prepared for considerable amount of bad habit and spotting of leaves if any of the members of the Indian group of Saretha canes are used as parents, that early maturity could be introduced by using Co. 214, D. 74 and 100 P. O. J., and that late maturity generally results from using *Saccharum spontaneum*.

III. Selfing and use of cloth bags in sugarcane breeding.

The Coimbatore experience in the matter of selfing is rather limited, as it was early found that this line of work was not likely to be of use in the solution of the Indian problem. Enclosing sugarcane flowers inside cloth bags, either for selfiing or for protecting the artificially cross-pollinated arrows from other undesired pollen, had also soon to be given up as serious defects were noticed.

Firstly, the bagging was found to have an adverse influence on the seeding of the enclosed arrow, attributable apparently to the rather unnatural conditions obtaining inside of the bags; the temperature inside of the bags was found to be higher than that outside, sometimes, by as many as ten degrees.[1]

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[1] Venkatraman, T. S. Arrowing in the sugarcane with special reference to selfing and crossing operations. *Agri. Jour. India*, Special Indian Science Congress No., 1917, p. 107.

Secondly, it was found that cloth of even fine texture did allow a certain amount of pollen to pass through its meshes. On more than one occasion, arrows carefully bagged showed in the resultant seedlings unmistakable indications of foreign pollen. One rather remarkable instance of the kind was the free germination of an arrow enclosed in muslin, the arrow not possessing any fertile pollen of its own. In this instance the seedlings obtained showed on germination unmistakable signs of the blood of a wild cane flowering in close vicinity.

Certain observations made while extensive bagging was in practice are here recorded. The bags in the field need constant and careful supervision to prevent entry into them of rats and squirrels which often find in them a snug abode for themselves and their little ones, the rather warm fuzz coming in handy for nesting and bedding. Secondly, the bags are best held firmly in their position by planting the main supporting bamboo on the windward side and further fastening the bag to a shorter bamboo planted on the opposite side. Thirdly, the bags require constant lifting up and adjustment to prevent the vigorously growing arrow from touching the bags at the top and incidentally exposing the stigmas to pollination from outside through the meshes of the bag. Fourthly, in the event of rain the arrows soon develop fungoid growths, doubtless due to the warm and humid conditions prevailing inside the bags, and need to be collected as quickly as possible after they are ready. Fifthly, the bags need inside of them some kind of frame work to stretch them out and not allow the cloth to touch the arrows inside of them. Both iron and bamboo frame works were used ; the latter are preferable as they keep the bags cooler.

IV. Cross-pollination in the sugarcane.[1]

As already mentioned, the bulk of the seedlings at Coimbatore have been obtained through cross-pollination. The more important of the methods employed are briefly described below, mentioning the advantages or disadvantages associated with each.

(1) *Emasculation.* After trial for two years emasculation had to be given up as unsuitable because of (*a*) the extreme delicacy of the floral parts, even a violent bending of the axis sometimes prejudicially affecting the seeding of the arrow, (*b*) the minuteness of the parts necessitating the operations being done under a high magnifying lens, (*c*) the inconvenient height at which the operations had to be carried in the field, heights of fifteen feet from the ground not being uncommon, and (*d*) the slowness and the paucity of results, a large number of the operated flowers withering away from handling. If anything, it was particularly unsuited to the Coimbatore station which, in the first instance, was sanctioned experimentally for a period of five years.

(2) *Bagging together arrows of the two parents.* This consists of bringing together inside the same cloth bag arrows of the two parents and trust to the crossing taking

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[1] See also Venkatraman, T. S. *Pusa Agri. Res. Inst. Bull.* 94, pp. 8 and 9.

place inside of the bags. The method was, however, found to possess serious defects. Firstly, it was not always possible to bring the desired arrows into the same bag however close the varieties may have been designedly planted in the first instance. Secondly, it was found that the juxtaposed plants sometimes either did not arrow at all or arrowed at different dates. Thirdly, the arrows often came out at different heights rendering their being bagged together very difficult, if not impossible.

(3) *Placing inside the bag each day an arrow of the pollinating parent.* The arrow which it is desired to use for pollination is cut the previous evening, the bottom of the stalk stuck into a bottle containing water and hung up inside the bag a little above the enclosed arrow. Next morning the anthers protrude, liberate the pollen and cross-pollination is secured. The liberation of the pollen is sometimes facilitated by an operator going round the next morning and gently tapping the arrow at the right time. The pollinating arrow has to be cut at a stage when it is likely to yield the maximum amount of pollen on the succeeding day, *i.e.*, when the anther protrusion in the arrow, which is generally from top downwards, is within one-third from the top. Sometime after the pollination the arrow has to be removed from the bag to avoid its seeds getting mixed with those of the pollinated arrow. In this method each day and for each pollination one arrow of the father has to be sacrificed. The operation has to be repeated from three to four days to ensure a satisfactory pollination of the bulk of the stigmas in the mother arrow. The method has proved very satisfactory apparently because the pollen remains in its own receptacle till actually liberated when it falls directly on the stigmas. The method has been in use at Coimbatore from the year 1912.

(4) *Dusting the mother arrow with collected pollen.* This consists in surrounding the father arrow with a tissue paper bag some time before anther protrusion, gathering the pollen immediately after anther dehiscence and dusting the pollen over the mother arrow. The pollen has to be used almost immediately after collection because it quickly loses vitality; this greatly limits the number of cross-pollinations that can be effected on a particular day. The method does not lend itself to the effecting of a large number of different cross-pollinations, except with a correspondingly large number of operators. It has one advantage over the method previously described in that the arrows of the pollinating parent need not be destroyed and hence are available for pollen collection from three to four days. In this method also the pollinations have to be repeated three to four days to ensure a dusting of the bulk of the stigmas.

For some time, blowing the collected pollen on to the stigmas by means of a 'blowing ball' was attempted, the pollen being kept in gelatine capsules.[1] Great economy of pollen resulted therefrom but the inevitable handling associated with it has thrown it rather into disfavour in recent years.

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[1] Venkatraman, T. S. A simple pollinating apparatus. *Agri. Jour. India*, Vol. XVI, Pt. 2 p. 203.

(5) *Dusting the mother arrow with pollen preserved largely in its own anther-sacs.* In this method, such branches of the pollinating arrow as are likely to protrude their anthers during the day, are scissored off fairly early in the morning and well before anther protrusion in the arrow. Ability to pick out such branches comes easily with a certain amount of experience. The branches are now wrapped loosely in tissue paper, each paper packet containing a few of the branches. The paper packets are now stored in small bamboo baskets very much like the ones used for storing and transporting fruits and vegetables, *i.e.*, baskets with plenty of air holes in them. Care is taken to see that in a basket the packets of only one variety are stored ; this is done to avoid mixtures. The baskets are now stored until needed in the cool shade of the sugarcane plants. When the mother arrow is ready for pollination, the basket with the paper packets is taken to the place, one of the paper packets gently unwrapped and the arrow branches shaken over the stigmas it is intended to cross-pollinate. If during the operation a perceptible pollen cloud is not noticed, a second packet is taken out of the basket and is similarly dealt with. The chief advantage of the method lies in the fact that inside the paper packets the pollen continues viable for a longer period than otherwise, sometimes by two hours. This prolonged viability has been established both by artificial germination of the grains and also from the seed setting of the arrow after the operation. It has been found that, even if the anthers do open inside the paper packets, the pollen largely remains in the sacs and is mostly liberated only as the branches are shaken over the stigmas. This is the method now largely in vogue and has been found the most satisfactory, so far, in efficiency, economy of pollen employed and economy in the number of operators that are needed for effecting the same day a large number of cross-pollinations.

Use of bags in cross-pollinations.

In view of the adverse effect on seed setting and the other defects connected with the use of cloth bags already mentioned, experiments were made at leaving the cross-pollinated arrows unbagged and the results obtained appear to be satisfactory. It has been found that, so long as the artificial cross-pollination is done at the right time and with plenty of the desired pollen of proved vitality, the results are by no means unsatisfactory. In such cases the desired effect appears to be attained by the pollen employed getting a start over other wind-borne pollen that may reach the stigmas later. The efficiency of the pollination can be enhanced by surrounding the pollinated arrow with a paper cylinder at the time of dusting. The arrangement, by confining the pollen to a smaller cubic space round the arrow, secures a more efficient pollination.

It has to be admitted that unbagged crosses effected in the above manner will not furnish satisfactory material for a scientific study of the laws of inheritance in the sugarcane ; but against this it has to be remembered that even cloth bagging does not absolutely rule out access to outside pollen. In breeding work, undertaken

chiefly with the idea of rapidly achieving practical results, the method has a wide sphere of usefulness. This method has been in use since 1916.

Cross-pollinating varieties rich in own pollen.

For a long time it was the practice to pollinate artificially only such varieties as do not possess healthy pollen of their own; such varieties were chosen because of the impossibility of the collected seeds including any selfed ones. The very varied needs of the station, however, rendered it desirable to employ a wide range of parents including those which possess healthy pollen of their own. Experience gained during the last half a dozen years has shown that the desired crosses, with but very little chances of selfed seeds, could be obtained even from the latter class of varieties by pollinating the mother arrow at the right time and with plenty of the intended pollen well before the dehiscence of its own anthers. In these cases the desired result appears to be obtained from the dusted pollen getting a good start over any self pollen that may reach the stigmas later.

The above pollination is particularly easy when the tropical kinds are used as mothers and the Indian varieties as fathers. The anthers of the former class, generally, open much later in the day than those of the latter class, a difference of two hours having been noticed in certain cases.

Pollen viability tests.[1]

In all such work it is important to test the pollen used for viability at each stage. In the earlier years a great deal of time and energy was wasted owing to the non-availability then of a reliable test for viability. In the year 1920, however, a satisfactory test was discovered. The pollen, it is desired to test, is sown on live stigmas of *Datura fastuosa* when viable pollen quickly germinates. Other workers have used the stigmas of the tobacco plant for the purpose.[2] Frequent tests for viability are very important in the sugarcane because of the rapidity with which its pollen loses viability.

Preservation of cane pollen by controlling anther dehiscence.[1]

It was often found that the two varieties, it is desired to cross with each other, arrowed in different places separated from each other by railway journeys of varying periods. Experiments undertaken for preserving pollen during transport have yielded a fairly satisfactory method. The method essentially consists in preventing the anthers from protrusion and dehiscence by creating humid conditions around the sugarcane arrow during transport. So far it has been possible to preserve pollen in this manner for about ten days.

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[1] Venkatraman, T. S. Germination and preservation of sugarcane pollen. *Agri. Jour. India*, Vol. XVII, Pt. 2, p. 127.

[2] Mameli Calvino, E. Studies in anatomy and physiology of sugarcane in Cuba, 1921.

Fig. 1. An arrowing plot at the Coimbatore Breeding Station.

Fig 2. The earthenware pots in which cane arrows are sown. A batch of labourers are seen pricking out from overcrowded pots.

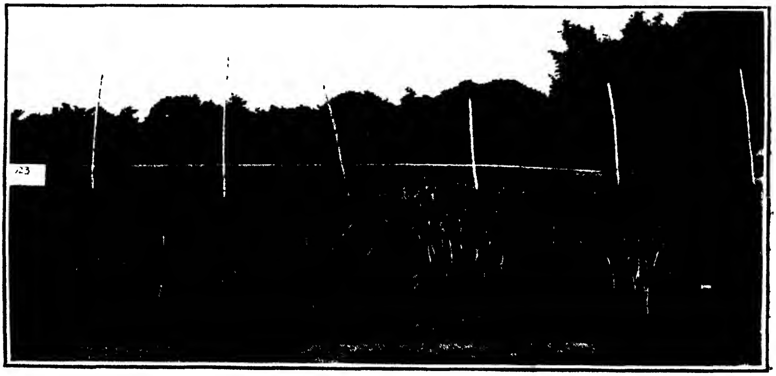

Fig. 3. Raised beds in the first ground nursery.

A striking use of this method in a rather difficult cross-pollination is described below. It was desired to effect a cross between *Saccharum spontaneum* as mother and the tropical cane Karun as father; but this was rendered difficult from the fact that the anthers of the former open much earlier than those of the latter, the approximate timings being respectively 6 A.M. and 8-30 A.M. By preserving the arrows of Karun in a special crate the above cross has since been successfully accomplished The resultant seedlings now growing at the station show, in some of them, unmistakable traces of Karun blood. The above cross was effected in 1922.

Test for pistil fertility.[1]

For a long time past the presence of starch inside the cells of the style branches has been used as a sign of pistil fertility. The test has enabled the raising of crossed seedlings with a high degree of certainty as to results. Other workers, however, have not found the test quite reliable. The correlation was, therefore, re-examined within the last two years, over 300 varieties and seedlings being subjected to the test. It has been found that, whereas it is a test of considerable value in the Indian varieties, it does not work satisfactorily in the tropical canes and breaks down in the case of new seedlings. This is of some interest and needs further investigation.

Value of special arrowing plots in sugarcane breeding.

It has been found a great advantage to plant what in the station are termed 'arrowing' plots (Pl. XII, fig. 1) for carrying on the cross-pollination work. These are special plots laid out away from the main fields and are sometimes situated under different conditions. They are also sown, often, at a different time from the main plots. Certain of the advantages derived from them are here mentioned. Firstly, as varieties differ considerably in their value as parents, the special plots enable the growing of a large number of plants of the most desirable parents. Secondly, canes intended for arrowing sometimes need a treatment different from that for the main plots. It has been found that a vigorous growth in the early stages followed by a check, induced at Coimbatore by special ill treatment of the plants, is conducive to arrowing; the special plots enable such treatment being given. Thirdly, varieties in such plots frequently arrow at a time slightly different from those in the main fields, undoubtedly due to the difference in treatment. The slight differences in the time of arrowing have often materially helped in the cross-pollination work. Indeed it would appear profitable to plant the useful parents under as many conditions of soil and irrigation as may be available at any station.

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[1] Venkatraman, T. S. Arrowing in the sugarcane with special reference to selfing and crossing operations. *Agri. Jour. India*, Special Indian Science Congress No, 1917, p. 105.

V. Collection and storage of sugarcane arrows for sowing.

The best stage to collect arrows for sowing is when the florets begin to separate from the top branches and drop off. Even arrows, collected at a stage as immature as to have the anther protrusion still in progress from the bottom branches, have been known to germinate from the top branches ; such seedlings generally turned out to be weak and showed a high degree of mortality.

In an arrow the largest number of fertile seeds are generally found in the top two thirds. Should there be rain, the arrows need to be collected some little time after to allow their drying ; arrows containing moisture quickly develop fungoid growths on storage.

Immediately after collection the arrows are loosely packed in tissue paper with full details written on a label placed inside of the packet and on the outside of the paper wrapper. Only a few arrows—not more than ten—are placed in each packet ; this is done to allow good aeration. These packets are dried in the sun for a couple of days to eliminate any moisture in them.

The packets are then taken to a closed room and the fluff collected on a sheet of tissue paper spread on the ground, the dislodgement being facilitated by tapping the arrow or gently passing the fingers down the arrow. In this operation the arrows are held over the paper bottom upwards. The collected fluff is again wrapped loosely in tissue paper and labelled as before. The packets are not to be stored in great heaps or inside closed receptacles ; they need plenty of ventilation and are best spread out on tables. The stored packets need protection against rats and ants. These are generally sown about two weeks after collection and, though definite experiments have not been made, the impression has been formed that, if sown immediately after collection, the seedlings exhibit a higher mortality.

VI. Germination and the early stages of growth.[1]

Sowing and germination.

For sowing, shallow, circular country earthenware pans—12″ across at top, 9″ at bottom and 6″ high—have been found satisfactory (Pl. XII, fig. 2). Previous to sowing the pans are numbered with some water-proof paint. Suitable provision having been made for free drainage at bottom, the pans are filled with a mixture of equal parts of well rotten horse dung and sand. The fluff is now laid in an even thin layer on the surface and the first watering done from a garden rose held 3 feet above the pans. The force of the impact gathers round the tiny seeds a small amount of soil and this facilitates germination. The quantity of water employed should not be such as to form a pool in the pan as it leads to the seeds all getting to one side and germination is affected. Immediately after sowing the pans

[1] See also Barber, C. A. *Mem. Dept. Agri. India, Bot. Ser.*, Vol. VIII, No. 3.

are arranged in groups—each group containing all the pans of a particular lot—and each group is separately labelled with details as to variety sown, date of sowing and other useful particulars. For this purpose paper labels first written in pencil or Indian ink and subsequently dipped in melted paraffin wax have been found useful; they are unaffected by the frequent watering.[1] Germinations have not been noticed earlier than three days from sowing; and pans not germinating within a fortnight have rarely been found to do so later.

Watering.

At Coimbatore it has been found necessary to water the pans as often as three to four times during the day. The watering is always done through a garden rose. For proper germination it has been found necessary to keep the fluff always moist. After germination the plants need much less water as the roots quickly develop and traverse a good bit of soil. The young cane plants are often very susceptible to excess of water and quickly turn yellow.

Precautions during early stages.

It has been found useful to place the seedling pans on raised bamboo platforms about $2\frac{1}{2}$ to 3 feet from the ground. Besides facilitating constant inspection of the young plants the arrangement is of use against ants and crickets. It has been found best to place the seedlings in full sun. The young sugarcane plants appear to revel in the sun and are rather susceptible to any kind of shade. In one instance the circular shade from a coconut crown marked off a corresponding circle of weak and unhealthy plants in the pans placed under it.

Weeding and thinning of sown pans.

The appearance of a large number of grass seedlings, which in the earlier stages look much like those of the cane and hence are difficult to weed out, is a trouble of some importance. At Coimbatore the two weeds chiefly met with in the pans are *Chloris barbata* and *Cynodon dactylon*. The number of these could be greatly minimized if the horse dung, which is apparently the chief source of infection, is pitted for a couple of months before use and periodically watered. The heat generated in the pits is believed to cause the death of the grass seeds. As an additional precaution the filled pans are allowed to remain unsown from ten to twelve days and occasionally watered during the period. The grass seedlings that come up are pulled out and the pans are now ready for sugarcane sowing. The very few grass seedlings that appear even after the above precautions are easily removed by trained labourers. Should the pans be found very crowded, and contain say

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[1] Venkatraman T. S. Labelling in experimental stations. *Agri. Jour. India*, Vol. XV, Pt. 1, p. 45.

more than two or three hundred seedlings, they need pricking after a fortnight into a second set of pans. If the germination is thinner the pans may be left till they are ready for planting in the first ground nursery.

VII. The first ground nursery.

Fields with a fair admixture of sand are chosen for this as well as for the second ground nursery. They are prepared as for an ordinary cane crop, except that the surface needs to be cultivated with extra care to secure a fine tilth. Raised beds are formed, each bed being two feet broad, four inches high and any convenient length, the last depending on the lie of the land (Pl. XII, fig. 3). The beds are spaced two feet apart, the soil between adjacent beds being used for forming them. The space between the beds facilitates constant inspection of the young plants.

Seedlings are transplanted to this nursery after they have been a month in the earthenware pans and, as far as possible, with a little ball of earth round the roots. The seedlings are planted out in rows running along the breadth of the beds with a spacing of two and a half inches between rows and one inch between plants in the row. For marking the positions of the plants, a bamboo frame work with nails driven in at suitable distances has been found useful. The beds are watered immediately before and after the transplanting, the former to receive the seedlings and the latter to compact the soil round the roots.

Watering of the beds is done with a garden rose till the seedlings are well established, when irrigation from channels laid in between the beds can be started. It is desirable, however, to postpone the latter kind of irrigation till the plants are strongly rooted. Seedlings that may get slightly dislodged during the waterings should be carefully placed in position and the soil round them compacted; this is necessary chiefly soon after the transplanting.

When the seedlings are grown about four inches, a combined hoeing and earthing is given by drawing firmly a sharp piece of bamboo in between the rows. With this operation the soil automatically heaps itself a little on both the sides of the seedling rows. No shade is raised over the plants. The plants are allowed to grow in this first ground nursery for about two months when they would be found to have grown to about nine to twelve inches. While planting into this nursery no selection is made; only the dead and the very meagre plants are left behind in the pans.

VIII. The second ground nursery.

Land for this nursery is prepared in the same manner as for the first. It is then marked into plots, each plot being ten feet wide and of any convenient length. Drains, irrigation channels and paths are formed as indicated in the plan (Fig. 1). Each plot has an irrigation channel on one side of it and a drain on the other. Each

drain serves the two plots on either side of it and the irrigation channels between two adjacent plots are separated by a path.

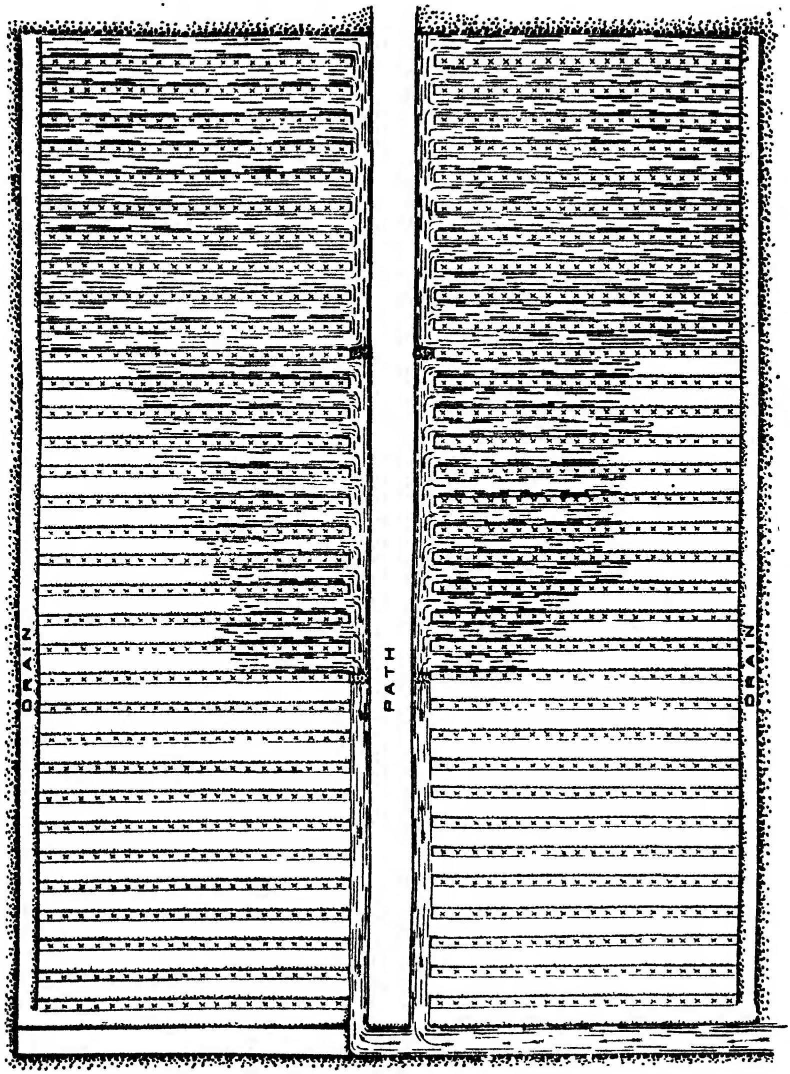

Fig 1. Irrigation of the second ground nursery. The arrows indicate the direction of flow of water in the irrigation channels. The crosses in the plots denote the positions of the sugarcane plants. They are on raised beds and water is never allowed to reach to their stems. The diagram indicates the manner in which the trenches get filled from the farthest end. The trenches in this plot are being irrigated in batches of eleven at a time.

The plants in the first nursery are prepared for transplanting into the second by a rather drastic trimming of the leaves to compensate for the loss of roots during the uprooting and the transplanting operations. With the help of a hand hoe shallow V-shaped grooves are cut into the ground along the width of the plots at a distançe of eighteen inches from one another. The prepared plants with balls of earth round the roots are placed in these grooves six inches apart and slightly watered. The removal of plants from the first nursery with balls of earth round the roots is greatly facilitated by the condition of soil in that nursery and by the fact that the plants are in beds raised from the ground level; the latter enables an operator easily to work round the plants. The plants are placed in position in the rows by raising a ridge of soil all along the row. Immediately after the ridging a copious irrigation is given to the plot.

For satisfactory results it is essential that the irrigation in the second nursery should be gentle, copious and of a soaking nature. This is secured by irrigating at the same time ten to twelve rows in the plot and by handling more than one plot at the same time. Water is led into the irrigation channel of the plot right to the farthest and lowest end. As there are no bunds separating the irrigation channel from the trenches between the rows of canes, water would first fill in the end rows. When ten to twelve rows are thus irrigated, a bund is placed across the channel and a second set of ten to twelve rows receive the water. These rapidly fill in when a second bund is placed across the channel and water turned on to a third set of rows. A plan is given indicating the manner in which the irrigation is done (Fig. 1). In this irrigation water never touches the stems or leaves of the seedlings as they are situated on raised ridges. The drain in between the plots is of considerable use for drawing off any excess of water in the trenches after rains or an irrigation. The irrigation above described consumes a fairly large amount of water but it appears to be necessary for a satisfactory and uniform growth of plants in the second nursery. At Coimbatore such irrigations are given about once a week.

No shade is raised over the seedlings in the second nursery ; any shading only prolongs the life of the weaklings. When planting from the first to the second nursery no special elimination is attempted. It would appear to be rather risky to attempt any eliminations before the full growth in the second nursery; certain seedlings which were rather poorly in the first nursery have suddenly bucked up in the second and have since proved useful in the districts. Such sudden progress in growth of seedlings is often associated with a sudden and rapid development of the roots at the time.

Trouble from white ants is sometimes experienced in the first and the second nurseries. Use of partially decomposed manure, often containing half decomposed fibrous material, is a great attraction for the pest. Tar-emulsion has been found of use in fighting it. The emulsion is prepared by dissolving a pound of soap in the same weight of water, boiling it and adding gradually about a pound of coal-tar during the boiling. The emulsion can be kept for sometime and, when needed, is diluted with water to make a half to one per cent. solution. One per cent. solution

of this emulsion kills soft-leaved delicate weeds. The solution is applied to the trenches from a garden rose before an irrigation. The irrigation water, as it sinks down, carries the solution along with it and helps to keep out the pest. Another common pest is the shoot borer (*Diatræa auricilia*) and no satisfactory remedy has yet been found for this.

IX. Plots for testing.

From the second nursery the seedlings go to the final plots for testing. Here they are grown for well over a year and their botanical, agricultural and chemical characters studied all through the period. It is only at the time of planting in the final plots that any real selection of the seedlings is practised. The selection is made on a large number of characters, vigour, habit and tillering being the more important of them. Some idea of the extent to which natural and artificial eliminations are made from germination to final planting would be gained from the numbers for the 1923-24 batch of seedlings. Out of one lakh and thirty thousand seedlings that germinated, about a lakh were planted in the first nursery ; eighty thousand of them reached the second nursery and in the final plots it is expected to plant out about ten thousand for the full year test.

The planting in the final plots differs from the others in one important respect. Whereas in the latter the seedlings are moved more or less intact, the final plots are planted from setts obtained from the seedlings. The nearly six-month growth in the second nursery is generally sufficient for cane formation in the seedlings. The immaturity of the setts at the time of planting does not appear to be any disadvantage. On the other hand, they germinate very readily and very few gaps are noticed in the final plots. There is yet another advantage in planting the final plots from setts instead of with the seedlings themselves. When, in the earlier years, the seedlings were transferred to the final plots almost intact, it was noticed that they exhibited a rather abnormal vigour, *i.e.*, a vigour not always maintained when the seedlings were multiplied from setts later on. With sett planting a more dependable vigour is available for observation at the time of selection. The importance of this will be realized when it is remembered that the subsequent multiplication of useful seedlings is entirely from setts.

The period from germination to final planting occupies about nine months. The cane arrowing season at Coimbatore is October-November. By the beginning of January the seedlings would be germinating. They are moved into the first nursery in January-February and into the second in April-May. They grow in the second nursery till August-September when they are ready for planting into the final plot. They remain in these plots well over a year, *i.e.*, till past next September. Coimbatore possesses two seasons for the planting of canes ; one in garden lands about February and the second in wet lands July-August. The planting in the final plots is done about September towards the end of the second planting season at Coimbatore.

The testing plots are planted as indicated in the plan (Fig. 2). The seedlings are arranged in square blocks of one hundred and the parents, the grandparents, and sometimes the standard canes also are planted at the extreme sides of the p'ots.

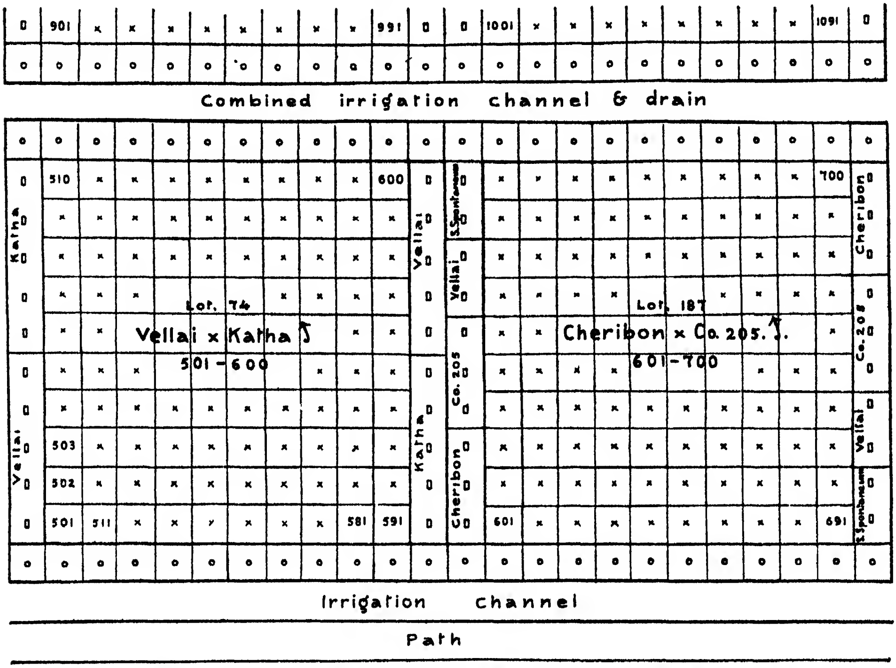

Fig. 2. The final plot for testing seedlings. The crosses denote the positions of the seedlings, the oblongs those of th parents and grandparents and the circles those of fodder plants placed along the borders.

Whenever the seedlings are studied or their juices chemically analysed, the parents and others are also dealt with at the same time. As the main object of breeding is to obtain types, which are definite improvements on the parents or the standard canes, the advantage of having them always near and growing under practically identical conditions is obvious. The manner in which the seedlings are numbered in the plots is seen in the plan.

It was frequently noticed that the border plants of a cane plot—those adjoining a path, an irrigation channel or a drain—showed markedly greater vigour than those inside the plots. At the time of selection it was found difficult to decide, in the case of a border plant, how much of its vigour was due to its advantageous position in the matter of light, air and water. To render the conditions of growth in the plots more uniform the borders are planted with a row of some fodder grass or a standard cane. This is cut out immediately before the plot is taken up for the final studies with a view to selection.

WHEAT HARVESTING EXPERIMENTS AT LYALLPUR.

BY

D. P. JOHNSTON, A.R.C.Sc.I., N.D.A.,

Deputy Director of Agriculture, Punjab, Lyallpur.

In the Punjab, the wheat harvesting season extends over a period of about two months. Commencing in the east about the end of March it gradually spreads, finishing up in the west about the end of May. From the time the crop commences to ripen in any particular district until the time it is all cut is usually only two, or at the most three, weeks. Of the cultivated land in the province about 30 per cent. is under this crop. It will, therefore, be readily understood that the problem of finding the necessary labour to harvest such a large area in such a limited time is an acute one. As more land is brought under cultivation in the newly irrigated tracts this difficulty is sure to increase. Even now competition for labour is forcing up wages to the economic limit, and unless more economical methods of harvesting —than at present prevail—are adopted, zemindars will be compelled to reduce the area of wheat grown.

In anticipation of such conditions arising, the Agricultural Department have for some years now been experimenting with various kinds of harvesting machinery in order to find something suited to the needs and conditions of the province. The results of this work are briefly indicated in the present article.

The ordinary hand hook *datri* is still one of the most efficient implements for dealing with small areas, or large, for that matter, provided there is a sufficient and cheap supply of labour. The hand hook in Europe has disappeared many years ago, driven out of use by conditions which are slowly making themselves felt here. There it was replaced, firstly, by a much larger form of hand implement called a scythe, later by animal driven cutting machines. Efforts were made to introduce these scythes on the Lyallpur farm but with little success. Labourers were loath to assume the upright working position required or to exert the necessary skill and energy demanded by their use.

In the year 1906, a bullock power reaper was introduced by Mr. Milligan, then Deputy Director of Agricultuie at Lyallpur. This machine has been improved from time to time and is still as efficient as any other on the Indian market. There are several hundreds of them in use throughout the province.

mostly purchased in pre-war days when prices were half what they are to-day. Zemindars now say that they cannot afford to purchase them but express their willingness to buy a cheaper machine of this or any other make if available. In order to try and meet this demand the department imported two cheaper machines, one of British, the other of American manufacture. These have been worked and tested at Lyallpur during the last two seasons. One gave entire satisfaction, while the other required some alterations before it could be worked successfully with bullocks.

The American machine is of the floating-bar type in which most of the knife-bar weight is carried on a large spring, instead of on the usual shoe and divider wheels. This arrangement enables it to negotiate irrigation ridges easily, and reduces its draught which was found to be less than that of three other makes tested under similar conditions. When drawn at the slow pace natural to bullocks it seemed to cut with greater ease than the others ; this was probably due to its greater speed ratio of crank to driving wheel (30 to 1). In most machines intended for horse draught the speed ratio is 25 to 1. A wood connecting rod operates the knife, to this it is attached by a special kind of ball and clasp connection. Disconnecting the knife in this machine is a troublesome operation : the ordinary hook and eye joint as in the Raja reaper is much simpler and better suited to Indian conditions. This like most reapers being designed for use with horses could not be worked satisfactorily by bullocks until certain lever connections had been lengthened ; only then could the cutter-bar be lowered unto the ground. Horses carry the beam fastened to the collar underneath their neck at about 2 feet 9 inches from the ground, while bullocks carry the beam attached to the yoke on top of their necks at a height of 4 feet from the ground. This difference in height of carrying the beam necessitated these alterations. A wooden divider with a long fixed point was fitted to the machine, this frequently got broken on the irrigation ridges ; eventually it had to be replaced by a short iron divider ; this was fitted with a moveable point which was free to rise and fall with the contour of the ground.

The British machine was received fitted out as a mower ; it, therefore, could not be tried until reaping attachments were obtained from England a year later. Mower attachments are seldom or ever required in the Punjab and should only be supplied as an extra at the request of the purchaser. On trial this reaper proved quite satisfactory ; no alterations were required to enable it to be used with bullocks.

Both these reapers have the cutter-bar attached on the right hand side. As bullocks are used turning to the left in performing most farm operations, they are rather troublesome to control when working in a right-handed reaper. It would therefore be advisable if left-handed reapers only were imported into the country.

A self-delivery reaper has also been tried. These machines differ from the reaper, in that they have an automatic mechanism in place of a man for sizing and sweeping of the bundles. Moreover the bundles are deposited at the side about six feet away from the uncut crop. (The ordinary reaper deposits them behind.) An unobs-

tructed path is therefore left in which the bullocks can continue working until the field has all been cut. Labourers can come along afterwards at any convenient time to tie up and stack the crop. (If an ordinary reaper is to continue working, six or eight men are required to remove the cut crop from its path.) Taking a four-foot wide cut this machine can be pulled by a pair of Hissar bullocks (average draught 260 lb.). Adjustments are provided for making the bundles any required size. In construction it is more complicated than the reaper ; the tilting rakes if not carefully watched go out of order and get broken. The only advantages in using this machine are that it is a temporary labour saver at a very busy season and that the crop can be thoroughly dried before being tied up ; the latter is an important factor in a country with a humid climate like that of Britain, but not in the Punjab.

Last year a self-binding reaper was obtained for instructional purposes at the Punjab Agricultural College, also to investigate its possibilities as a harvester on canal-irrigated lands.

Many people here think that self-binding reapers are still in the experimental stage and not to be relied upon, but such is not the case. They were first introduced into Britain about the year 1880 but not extensively used until the twine knotter was invented ; after that they increased in popularity until to-day almost every British farmer growing more than thirty acres of cereals is the owner of one of these machines. This is surely a very good indication of the measure of their popularity and success.

Self-binding reapers have been developed from the self-delivery reaper by the addition of a mechanical straw transporter and an automatic tying apparatus. The standing crop is cut by a knife similar to that in use in an ordinary reaper, revolving rakes push the cut straw backward on to a moving platform, this carries it to one side where it is caught up in an elevator and delivered unto a packing table, there it is compressed into bundles, automatically tied with twine and then thrown out on the ground. In most countries these machines are drawn by three horses, hence at least six bullocks would be required to do the work. At Lyallpur, owing to the impracticability of yoking and controlling so many animals, a motor tractor was used to haul it. During the harvesting season trials were conducted and some very successful demonstrations given ; all who witnessed these expressed themselves well satisfied with the quality of the work done.

Machinery cannot be used so advantageously in irrigated as in *barani* (rain-fed) lands owing to the small size of the fields and the great waste of time involved in too frequent turning. At Lyallpur, for convenience, some of the squares[1] have been laid out in five-acre strips. These can be conveniently irrigated by making temporary " cross-bunds " at intervals. These " bunds " should be not more than six inches high, a reaping machine can then pass over them without difficulty.

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[1] A square of land is about 25 acres.

The following is a comparison of the costs of harvesting wheat at Lyallpur by different methods :—

By Hand.

Five men are required to cut one acre in one day ; for this work they are given five bundles as payment. These five bundles contain roughly :—

	Rs.	A.	P.
65 seers[1] of grain at Rs. 4 per maund	6	8	0
98 seers of bhusa at As. 8 per maund	1	3	0

Total cost of harvesting an acre by hand Rs. 7-11.

By Reaper.

	Rs.	A.	P.
Interest on cost of machine, Rs. 500 at 10 per cent.	50	0	0
Depreciation at 15 per cent.	75	0	0
Lubricants	7	0	0
Cost of carborundum file for sharpening knife Rs. 6—Depreciation per season	1	8	0
Spares, repairs, overhauling, etc.	30	0	0
2 pairs of bullocks for 14 days at Re. 1 per pair	28	0	0
(There is no other work for the bullocks at this season.)			
8 men for 14 days at Rs. 1-8 per day	168	0	0
Total working costs per harvesting season	359	8	0

Assuming that the reaper cuts an average of five acres per day for 14 days, or 70 acres in the season.

Total cost of harvesting an acre by reaper is Rs. 5-2.

By Self-Delivery Reaper.

Cost of harvesting is the same as by reaper, Rs. 5-2 per acre.

By Self-Binding Reaper. (Tractor drawn.)

	Rs.	A.	P.
Interest on cost of machine, Rs. 1,200 at 10 per cent.	120	0	0
Depreciation at 15 per cent.	180	0	0
Lubricants	14	0	0
Cost of sharpening knives per season	1	0	0
Spares, repairs, overhauling, etc.	80	0	0
1 man for 14 days at Rs. 2 per day	28	0	0
Cost of twine for 84 acres. 84 seers at Re. 1 per seer	84	0	0
Pay of driver and total running expenses of tractor whilst harvesting 84 acres at Rs. 3 per acre	252	0	0
Total cost of harvesting 84 acres	759	8	0

Cost of harvesting an acre by self-binding reaper, Rs. 9.

[1] 1 seer=2 lb. ; 40 srs.=1 md.

The conclusions to be drawn from these experiments are that mechanical harvesters—such as are used in western countries—are adaptable to suit Indian conditions. The time saved by their use, not to mention the economy effected in harvesting in the case of the reaper is a strong recommendation in their favour. Labour difficulties are reduced and grain may be saved which otherwise might be shed, or damaged by storms if cutting is unduly delayed. The ordinary reaper is the most suitable and economical machine for use in this country; only the present high prices deter cultivators from purchasing them; should these fall to the pre-war figure, indications point to their use on a much extended scale, at least in the Canal Colonies of the Punjab.

In conclusion, the writer wishes to express his thanks to L. Nathu Ram, Agricultural Assistant, Lyallpur, for his assistance in carrying out the experiments and recording the data obtained.

PRIVATE SEED FARMS AND SEED DISTRIBUTION IN THE MANDALAY AND KYAUKSE DISTRICTS, BURMA.

BY

L. LORD, B.A.,

Deputy Director of Agriculture, Northern Circle, Burma.

ONE of the methods of crop improvement is to obtain a superior strain of the crop in question by selection, hybridizing or by importation. But in India at least the crop improvement work of an Agricultural Department does not end with the mere introduction of the improved strain. Arrangements have still to be made to bring the seed into the hands of all the interested cultivators. The problem is two-fold : (*a*) to produce and distribute yearly a sufficiently large quantity of pure seed and (*b*) to maintain the purity of the seed.

It was suggested that the way this is being tackled in the Kyaukse and Mandalay Districts and the results so far obtained would be of interest to others engaged in agricultural extension work. Although private seed farms in Burma are not confined to these two districts, conditions here are favourable for rapid development. The chief crop in each district is irrigated paddy, the irrigation being from Government canals. Over 238,000 acres were irrigated in 1923-24. The other crops grown are of minor importance, and the Mandalay Agricultural Station has been able to devote its chief attention to this crop. Two strains of paddy, Theikpan* Ngasein and Theikpan Taungdeikpan, have been produced by selection and are extremely popular with the cultivators. Both strains are superior in yield and milling outturn ; they contain no red grains ; the grains are of even size and there is consequently less broken rice in milling. Theikpan Taungdeikpan is preferred for local consumption ; Theikpan Ngasein is slightly longer lived and is grown for sale wherever the water supply is sufficient.

There are thus two favourable conditions for seed distribution in these districts ; first, irrigated paddy is by far the most widely grown and most important crop, secondly, superior and popular selected strains of paddy are available for distribution. A third favourable condition is the net work of co-operative credit societies covering the irrigated tracts of these districts.

In the past selected seed from Mandalay has been sold direct to cultivators, approximately 5,000 baskets† being sent out annually, and at the present time it is

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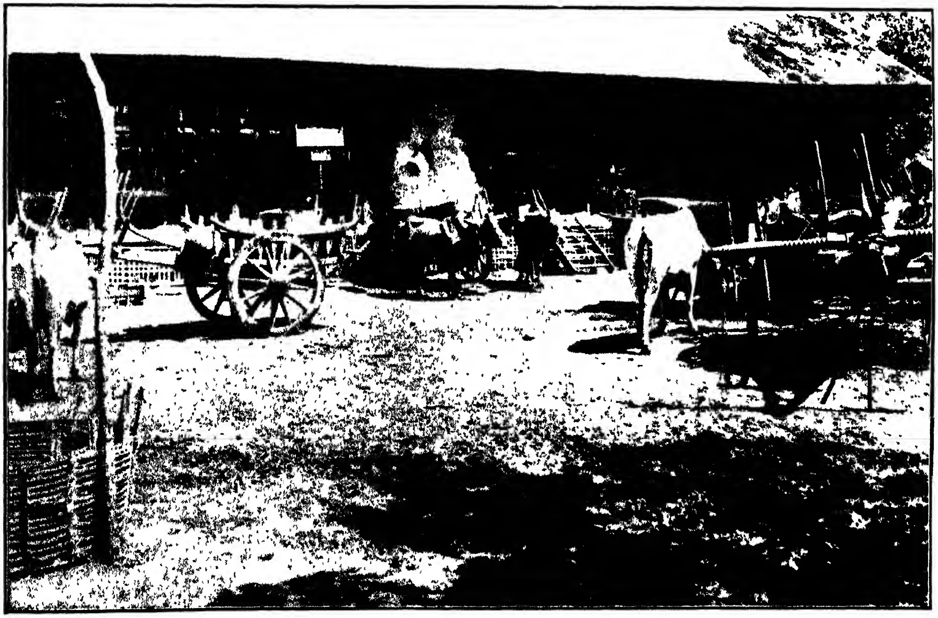
* *Theikpan* is a Pali word and is obtained from *Theikpan gyaung* (College). Cultivators have always called seed distributed from the Mandalay Agricultural Station *Theikpan* seed, so the word has now been used to distinguish all improved seeds given out by the department in this Circle.

† One basket=50 lb.



A PRIVATE SEED FARM IN KYAUKSE DISTRICT.
1, Fields; 2, Seed godown.

estimated that at least two-thirds of the irrigated area is under Theikpan seed of greater or less purity. This extension has been mainly natural spread as but comparatively very few cultivators could get the pure seed direct from Mandalay. In course of time a fair amount of mixing in the fields and on threshing floors must have taken place.

This method of seed distribution direct from an agricultural station has two serious disadvantages ; in the first place only a small amount of seed can be grown at the station, and in the second place when the seed is distributed there is no machinery to ensure that the produce is kept pure and is further distributed to other cultivators. As a matter of fact much of the produce is sold to millers who give a premium for Theikpan seed.

In order, therefore, to increase the available supply of pure Theikpan seed, it was decided in 1922 to establish private seed farms and the first of these were opened in 1923.

Essentially the method of procedure is as follows :— A cultivator is chosen of as good financial standing as possible who is willing to open a private seed farm. Pure seed grown at Mandalay is supplied to him annually at market rates, and whenever possible the whole of the seedsman's holding is planted with the same variety of paddy in order to lessen the chance of mixing. The farm is inspected periodically by the district staff of the department, and after harvest a sample of the grain is taken and sent to the Economic Botanist in order to test viability and purity. If these are satisfactory a certificate in English and Burmese is issued by the Deputy Director. The seed is then stored by the seedsman and sold to surrounding cultivators for seed purposes. The main difficulty is to ensure that the seed is stored and sold for seed purposes, as the cultivator has the habit of buying his seed at the last possible moment whereas the seedsman finds himself with various expenses to meet immediately after harvest. In practice the seedsman generally sells off immediately after harvest sufficient paddy to meet his expenses and stores the rest but in many instances where seedsmen are wealthy landowners all the seed has been stored.

The following table shows the result of the first year's working of the private seed farms :—

Private seed farms, 1923-24.

District	No	Area in acres	No of baskets of seed sold for seed purposes
Kyaukse	9	360·55	3,722
Mandalay	13	295·19	3,486

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A total of 7,208 baskets or 360,400 lb. were thus distributed to cultivators for seed purposes. In all the above seed farms the germination and purity tests of the seeds were satisfactory, and in many instances the purity was 100 per cent.

A study of the above table emphasizes the economic difficulties of seed distribution. The total area of the seed farms was 656·04 acres. An average yield of 30 baskets per acre may be expected, therefore the total yield of the seed farms was in the neighbourhood of 20,000 baskets. Yet only 7,280 baskets were sold for seed purposes. (The figures which made up this total were collected at the end of June, so it is probable that a little more seed was sold later, but at least half the seed produced was sold to millers and their brokers.) As mentioned above, one of the reasons that so much improved seed is sold for milling is that the cultivator does not buy his seed until the last possible moment, say, in May and June. The seedsman, however, requires money immediately at harvest time to meet expenses, so at that time part of the crop is sold to brokers. The two other reasons are—

(i) Many cultivators cannot pay cash for their seeds, so unless the seedsman likes to act as a moneylender, he is forced to sell the seed to brokers.

(ii) Cultivators who are tenants are very often supplied with seed by their landlords.

As already stated, the idea is to get men who are financially sound to open seed farms. Such seedsmen can afford to store the bulk of their produce until June. Landlords are also invited to open seed farms. In view of the economic position of the cultivator and the fact that this was the first year of the working of the seed farms, the results obtained are satisfactory. For 1925-26, it has been arranged to open 45 private seed farms totalling over 900 acres, but even with this increase the problem of pure seed supply has not been solved as seed for over 200,000 acres is wanted. By making use of the existing Co-operative Unions and Societies, it should, however, be possible to produce all the pure seed required. Up to now private seed farms haveall been individual enterprises although the majority of seedsmen are members of Co-operative Societies. In 1923-24, out of the twenty-two seedsmen, nineteen were members of Co-operative Societies.

The aim now is to get each Co-operative Union and Co-operative Society to have its own seed farm. Such farms may be Union or society farms or they may be run by a member of the Union or society. The Union farm will be supplied with seed direct from the Mandalay Agricultural Station, and the produce of the Union seed farm, after testing, will supply the seed farms of the societies in that Union. From the society seed farms, seed will go out to cultivators. Only the general scheme has been worked out at present, but as the last Agricultural and Co-operative Conference in Burma in 1923 was in favour of these farms it is hoped with the help of the Co-operative Department to start in the near future what will be co-operative seed farms and thus to overcome the present financial difficulties.

POSSIBILITIES OF PRODUCING LONG STAPLED COTTON IN INDIA.*

BY

G. L. KOTTUR, M.Ag.,

Cotton Breeder, Southern Maratha Country, Dharwar.

The need for long stapled cotton.

The demand for raw cotton is steadily increasing. It is estimated that the cotton industry of the world can easily absorb an additional half million bales every year. This is, however, true for stapled cottons. Cotton spinning is roughly of two kinds—coarse and fine. Coarse spinning up to 22 counts is done with cotton of $\frac{7}{8}$ inch in staple and below. Fine spinning of 32 counts and above requires cotton more than this staple. The number of spindles engaged in fine spinning is large and consequently the shortage of long stapled cotton is more acute. It is for this reason urged that an increase of 100,000 bales of long stapled cotton is more important to the world than an increase of 1,000,000 bales of short stapled cotton below $\frac{7}{8}$ inch.

The position of India as a producer of raw cotton.

Cotton is produced in many tropical regions but the chief supplies come from the United States, India and Egypt. The world's commercial cotton production can be roughly stated as under :—

Name of country	Number of bales (of 500 lb.) in millions
1. United States	12
2. India	4
3. Egypt	1
4. Other countries†	2
Total	19

It will be seen from the above figures that the world's cotton is practically produced in one country, *viz.*, the United States. This means that the cotton trade is at the mercy of that country, and it is for many reasons a most unfortunate position

* Paper read at the Agricultural Section of the Indian Science Congress, Bangalore, 1924.
† The commercial crop only is referred to in this case.

for all the countries which possess cotton mills. India has no doubt a considerable production but the bulk of her crop is so short in staple that it matters very little in the question of world statistics. The shortage to-day is of cotton $1\frac{1}{8}$ inch in staple and over, and of that India produces very little at present.

ATTEMPTS TO IMPROVE THE INDIAN SUPPLY.

The area suitable for cotton growing in India is large. About 22 million acres are annually under this crop but the yield is poor and the quality undesirable in many cases. Improvements are possible in both these respects. The possibilities of cultivation are great but those of breeding are still greater. We therefore believe with Sir Charles Macara that it is to India that the present generation will have to look for relief from shortage. Taking this view the British Cotton Growing Association has stimulated the Indian Agricultural Departments to take up the question. Every province is devoting some attention to this important crop and as a result substantial progress has been made in favourable regions. The present methods of marketing the produce are also defective and improvements in this respect are seriously contemplated. Thus every effort is being made to raise the value of the Indian crop in the world's markets.

HOW THE PRODUCTION OF LONG STAPLED COTTON HELPS INDIA.

India is not only a producer of raw cotton but also a manufacturer. She owns about 8 million spindles. The spinning done on these is, however, either thick or coarse from 1 to 22 counts. Yarn of 32 counts and over is produced in very small quantity--nearly $1\frac{1}{2}$ per cent. Fine spinning is not done probably for want of suitable local cotton. The production of suitable cotton, therefore, is much likely to develop our spinning industry in the direction of finer quality. Another advantage arising from the same would be to increase the net profit of the growers. At present the Indian mills consume nearly 80 per cent. of the good cotton produced, so that what remains for export is almost entirely inferior in staple suitable for spinning 16 counts and below. This quality has very little demand in foreign markets, and the result is that when it is exported the growers get low price for it. It is thus evident that the improvement of Indian crop is necessary not only in the interest of the world's cotton trade but also in the interest of spinners and growers of India itself.

THE KIND OF COTTON GROWN IN INDIA.

The cotton produced in India, though mostly short in staple from the point of view of Lancashire, can be classified as short stapled and medium stapled according to its spinning value. The short stapled class is almost entirely the production of *neglectum* cotton cultivated in Central India, Central Provinces, Berar, Bengal and Assam. It is suitable to spin yarn from 1 to 16 counts. The total quantity

of this comes to nearly three million bales. The medium stapled cotton is produced by *herbaceum, indicum* and *hirsutum* varieties of cotton cultivated in Bombay, Madras, Punjab and Hyderabad. It is suitable for spinning yarn up to 22 counts. Its quantity comes to about one million bales. Thus out of the total of four million bales produced, three-fourth is short stapled of very low spinning value and one-fourth medium stapled suitable to spin fairly good yarn up to 22 counts.

THE WAYS OF INCREASING THE PRODUCTION OF MEDIUM STAPLED COTTON.

The medium stapled cotton is more nearly equivalent to the general standard of the world's markets, and hence any increase in its production is advantageous. The outturn of stapled cottons already under cultivation can be increased by improvements in the present methods of cultivation. In the whole of the Kumpta cotton area the sowing is very defective. Hence good sowing alone can increase the yield by about 10 per cent. Similarly improvements in ploughing, manuring, etc., may do considerable good. But apart from these improvements for which there is scope in every tract, the outturn of lint can be increased by raising the ginning percentage. Some of the stapled cottons have a very low ginning percentage and it is possible to improve this character by selection. Kumpta cotton which gins only 25 per cent. is found to contain higher ginning strains, and by isolating one of them the percentage has been raised to 28 per cent. This means that an additional 7,500 bales have been secured without making any change in the present methods of cultivation. Selection thus may do the same thing for other cottons.

Improvement by selection, however careful it may be. has its limit which may only mean a small advantage. In such cases crossing followed by selection can produce better results All Indian cottons easily cross with one another, and we are fortunate enough to possess some varieties which have a very high ginning outturn. Some strains of Ghogari recently isolated in Gujarat are reported to gin as high as 46 per cent. By crossing the low ginning medium stapled cottons with high ginning ones the ginning percentage of the former can be improved to the standard of the latter. This can be done without injuriously affecting the other good characters such as yield and staple. Two pure strains, one of Kumpta with a low ginning percentage (28) and long staple (1 inch) and another of *neglectum rosea* with high ginning percentage (36) and short staple (½ inch), were crossed with the object of improving the ginning percentage and colour of Kumpta cotton. This cross has after careful selection continued for five years yielded pure strains which combine the desired characters of both the parents. These strains will be shortly sent out in the Southern Maratha Country to replace Kumpta cotton. The ginning percentage of stapled cottons growing in other tracts can be similarly improved by crossing and selection.

The effect of improving the ginning outturn of stapled cottons by the methods described above will be no doubt considerable, but if we take into account the fact

that three-fourth of the cotton produced in India is short stapled, no material alteration in the present situation is possible without improving the quality of the short stapled cottons. This can be done by the same methods described above, *viz.*, selection and crossing. But our scope in this respect is somewhat limited. We have no cotton possessing a staple longer than one inch that can cross with the Indian varieties. All we can do, therefore, by the way of improving the staple is to cross the short stapled cottons with varieties possessing a staple of one inch and obtain by selection pure strains with that length of staple. In this case also it is possible to improve the staple without affecting other good qualities. In other words, the much desired combination of the three economic characters, *viz.*, yield, ginning percentage and staple, is possible, and our ideal, therefore, should be to breed types with a ginning percentage of 45 and a staple of one inch suitable for cultivation in different tracts. It is, however, urged that long stapled cottons require a longer growing period and as such are not suited to grow successfully in the short stapled areas which have a short growing period. A critical examination of this statement is needed. The studies we have made in this connection indicate that no such difference exists between cottons possessing $\frac{1}{2}$ inch and one inch staple. For this reason we hope that there is good scope of improving the staple of the short stapled cottons.

Our dependence on foreign cottons for staple longer than one inch.

As already stated, the Indian cottons do not possess a staple longer than one inch, and this is in all probability the limit beyond which we shall not be able to go if we confine ourselves to these cottons. For all improvement in staple beyond one inch we have to look for other cottons. We have already some experience of growing foreign cottons in this country and this at present is not very much in favour of them. But it need not discourage us altogether. The number of cotton varieties in America is increasing every year, and we find that some of the recent varieties suit our conditions better. Again the cottons that are already acclimatized and cultivated on fairly large areas are capable of improvement and extension. The Dharwar-American cotton we have found contains two kinds of plants—hairy and glabrous. By isolating a superior strain of the hairy type we have succeeded not only in improving the yield and quality of that cotton but also in extending its cultivation outside the tract. Similarly we know that Cambodia cotton was once growing well on large areas and yielding cotton of staple longer than one inch. For these and other reasons we believe that the breeding of American cotton has good future in the production of long staple.

The use of the first generation hybrid in staple production.

It is a fact well known to cotton breeders that the first generation of a cross is often very profitable to grow as it possesses in general the desired qualities of both

the parents. We have found that by crossing a strain of Dharwar-American cotton with Sea-Island it is possible to produce in the first generation the same quantity of lint as Dharwar-American but of Sea-Island quality. The chief difficulty in this matter is that of obtaining sufficient quantity of seed every year for planting Some agricultural associations interested in cotton growing may make a business in this connection and give the seed to the growers. The Sea-Island cotton being very scarce and dear, the growers are sure to get the highest net profit even after purchasing the seed very dearly. There are no doubt other difficulties in the matter of seed supply, and the method has on the whole a limited scope in the areas which grow American cottons of inferior staple.

TREE COTTON AS A SOURCE OF LONG STAPLE.

Many of the tree cottons produce good staple and they were therefore once tried in this country for the sake of their staple. But they failed in many places and no one now seems to be keen about them. In spite of this it may be stated that there is considerable area in the Konkan[1] and other similar tracts which can profitably grow tree cotton. Tree cottons cross freely in the field and it is very difficult to get pure seed for planting. The plantation of tree cottons which the writer had an opportunity to visit, all contained hopeless mixtures of types Such a state can hardly be expected to produce good results. Again we have still to find out the best method of cultivating tree cottons under different conditions prevailing in this country. If these things are done, there is good scope for tree cotton growing in favourable regions. In this connection it may be stated that the first generation hybrid between two pure varieties preferably between Kidney and Peruvian is more profitable to grow.

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[1] Heavy rainfall tract of Bombay.

SELECTED ARTICLES

THE WORK OF THE IMPERIAL BUREAU OF MYCOLOGY.*

BY

E. J. BUTLER, C.I.E., D.Sc., M.B.,

Director.

The serious study of the depredations caused to cultivated crops by parasitic fungi and bacteria dates from comparatively recent times, and it was not until after the beginning of the present century that any organized attempt was made to ascertain the cause and seek methods of prevention of crop diseases in the tropical and subtropical parts of the Empire. As agricultural Departments were established in the various dependencies, officers were appointed who were charged with the duty of investigating the diseases of plants and devising means for their prevention or control. These officers are usually termed "mycologists," though the names "plant pathologist" or "phytopathologist," used in other countries, more aptly describe their functions. There are not far short of 100 such experts at present at work in the overseas parts of the Empire, all, with very few exceptions, attached to Government Departments of Agriculture.

In some cases these workers enjoy facilities not inferior to those available in the best equipped laboratories and research stations in England. In others and this applies particularly to the tropical areas, certain facilities are poor. The chief lacks in such cases are a good library and access to authentic specimens of the parasites known to cause disease in plants. There is nothing more discouraging than to find that work which has cost much time and labour has already been done somewhere else, or that a supposed new parasite has previously been studied and its ways are known. Even in the best equipped centres it is difficult to keep pace with the mass of research and practical work that is going on in many parts of the world, and to see and find time to read all the publications (many in obscure journals or difficult languages) that have a bearing on one's work.

In the past, assistance in such matters was provided by the Royal Botanic Gardens, Kew, and the British Museum of Natural History at South Kensington. Germany had carried the systematic study of the subject beyond the point reached

* Reprinted from *Empire Cotton Growing Review*, Vol. II, No. 1.

by any other country, and German assistance was almost indispensable to the overseas worker. With the outbreak of war the inadequacy of these arrangements became painfully evident, and both in England and in the dependencies means were sought to satisfy the requirements of the scattered band of mycologists throughout the Empire. The Imperial Bureau of Mycology was the result.

The Bureau was founded in consequence of a resolution of the Imperial War Conference passed on July 8, 1918. The subject was brought to the notice of that body by the Colonial Office, which, impressed by the success which had attended the efforts of the Imperial Bureau of Entomology, founded five years earlier to meet a similar situation in regard to insect pests, thought that the time had come to establish a like organization to deal with the other great class of destructive agencies in agriculture—namely, the diseases of plants caused by fungi. A number of the overseas Governments expressed their readiness to contribute to the support of the Bureau, and work was eventually started in September 1920. The affairs of the Bureau are managed by an honorary committee appointed by the Secretary of State for the Colonies, with Earl Buxton, G.C.M.G., as Chairman. Its finances are on a temporary footing, and negotiations are in progress to extend them for a period of five years from April 1, 1925.

The work of the Bureau falls naturally into two main divisions: it serves as a clearing-house for information on all aspects of plant pathology other than those concerned with insects and the like, and it examines and reports on specimens sent in from all parts of the Empire.

As a centre for information the Bureau endeavours to keep in touch with the work on the diseases of plants going on throughout the world. A staff of linguists is engaged in reading all the literature on the subject published in any part of the world to which access can be had, and in making abstracts of all original papers. These abstracts are printed monthly in a journal published by the Bureau, the *Review of Applied Mycology*. They are given in sufficient detail to enable workers in many cases to dispense with reference to the original paper, and are issued sufficiently promptly to keep up a survey of current activities in the whole field of plant pathology. The monthly numbers at present contain from 100 to 120 abstracts, and the volume for 1924 runs to 752 pages, exclusive of the index. The latter is in great detail, as the value of an abstracting journal in after years depends on the readiness with which references to particular matters may be looked up. No attempt is made to secure a satisfactory balance-sheet in regard to the *Review*: to do so would be impossible without charging a prohibitive price per copy, as the circulation is practically limited to the comparatively few who are directly interested in the subject. Hence an appreciable proportion of the Government grants is applied to the production of the *Review*, and copies are supplied free of charge to all the contributing Governments for the needs of their departments. At the recent Imperial Mycological Conference, held in London last July, a resolution was passed expressing appreciation of the service rendered by the *Review* to all workers on the subject, especially

those in the overseas parts of the Empire. It is probable that no branch of the work of the Bureau has been more widely approved than the publication of this journal, and its reception has been scarcely less cordial in America and on the Continent than within the Empire.

Another aspect of the information service is the furnishing to enquirers of references regarding previous work on a problem. In order to deal with such enquiries the Bureau aims at keeping up a comprehensive card index to the literature on plant diseases, and, in addition, maintains a large lending library of original papers in pamphlet form available for issue on demand. This library numbers over 6,000 items, cross-indexed by subject and author, and is increasingly being made use of by overseas mycologists. Extracts and translations from publications not easily available are also asked for at times, and requests for information of one kind or another are received in considerable numbers, almost by every mail. Recently a demand has arisen for copies of sections of the subject card index to be made available for some of the larger departments, and these are being issued at cost price.

The examination of, and reporting on, specimens sent from overseas is the second main activity of the Bureau. Progress in this branch of mycology is less advanced than in regard to insects. The fungus flora of a great part of the British tropical and subtropical dependencies is not well known; an enormous amount of work remains to be done before an adequate account could be given of, say, the fungi of tropical Africa. Plant disease surveys have been undertaken in some areas but these are, as a rule, confined to recording the diseases which cause notable damage to important crops. Unfortunately, a parasite that may be inconspicuous and relatively harmless in one area may cause a major disease in another. Many years ago the writer collected an insignificant leaf-spotting fungus on cotton in Kashmir which proved to be new to science. Nothing more was heard of this until, in 1920, a severe outbreak of a new disease of cotton was reported from Arkansas, and on investigation was found to be due to the same fungus. How it got from Kashmir to Arkansas (or *vice versâ*), and what countries in between it affects, are not known, but it is evident that every record of its distribution would be of importance.

Within the limits of the capacity of its small staff the Bureau tries to aid in gaining a more detailed knowledge of the fungi of the colonies. In some, such as Ceylon, little or no outside help is required, for such knowledge is already far advanced. In others, intensive collection is much needed, and it will be many years before the survey is completed. The number of systematic specialists available for the study of these collections in England is small, and progress is likely to be slow even with the aid of foreign workers.

In addition to this general systematic work, a large amount of time is devoted to the examination of individual specimens, often of obscure diseases or of parasites whose identification is difficult. In regard to this part of the work the position of the Bureau is somewhat like that of a consulting physician, except that it does not aim at dealing with all such enquiries itself, but passes many of them on to other spe-

cialists. In every case the idea is to get the best advice available, whether in England or abroad. The organization of the information side of the work is called into service here, since it is through the latter that the Bureau keeps in touch with active workers in various parts of the world and is usually in a position to know at any given moment who are working on any disease or group of fungi that the specimen may belong to.

A couple of cases illustrating this branch of the work can be taken from enquiries regarding cotton diseases that have been dealt with during the past year or two. The outbreak of black arm disease, caused by *Bacterium malvacearum*, in the Sudan is one of the serious problems which the Sudan Plantations Syndicate has to face. The Bureau has been in close touch throughout with Mr. R. E. Massey, the Sudan Government Botanist, in whose hands the investigation of this problem is placed. The first isolations of the parasite were sent to the Bureau to confirm its identity with *B. malvacearum*, and new cultures made from these were transmitted to Dr. Erwin Smith at Washington, the original describer of the parasite. He tested it fully, and reported that it was a variety of this organism, which was known also in the United States, but had not been described in detail. It is probable that without such an authoritative opinion there would still be doubt whether the disease was really black arm. Furthermore, the search for a satisfactory method of disinfecting the seed has been aided by the Bureau putting Mr. Massey in touch with institutions and firms most likely to be of assistance to him. The recent promising trials of izal against the same disease in the West Indies were arranged entirely through the Bureau. The prevalence of black arm in Nigeria has just been reported to the Bureau, which is thus in a position to put the local mycologist in direct touch with practically all that is known about it elsewhere.

A second interesting case is concerned with an obscure fungus which has been known to attack cotton and other plants in India for a number of years. More recently Mr. Briton-Jones, the late Mycologist to the Ministry of Agriculture in Egypt, found a similar fungus injuring cotton in that country. Dr. Shaw of Pusa, India, suggested that the Bureau should compare the parasite with a fungus, *Sclerotium bataticola*, which attacks sweet potatoes in the United States. Cultures of the Indian, Egyptian, and American fungi were grown side by side at the Bureau and proved to be identical. The curious thing is that the fungus has not been reported on cotton in America, while in the other countries it has not been found on sweet potatoes. Quite recently all three strains have been tested on sweet potatoes in Uganda, and all were found to rot the tubers just as described in America. In Uganda the same fungus infects beans, and will doubtless be found on cotton too, while from Nigeria it has recently been received on cotton and ground-nuts.

It can easily be realized that a single enquiry of the nature of those mentioned above may occupy several months and involve, in such cases as the last, a good deal of laboratory research. Apart from this kind of work, however, the Bureau does no original research, since it has always maintained the view that research into the cause and control of plant diseases must be done on the spot.

While the Bureau, for obvious reasons, works as a rule through the local Departments of Agriculture, its services are freely available to non-official mycologists. These are unfortunately few as yet, but the example set by the Indian Tea Association, the Rubber Growers' Association, and a few large corporations such as the Colonial Sugar Refining Company in Australia, in maintaining their own research staffs (including mycologists), is worthy of wider imitation. The existence of the central organization outlined above will undoubtedly make such a policy easier to adopt and will smooth the path of the individual workers in small, isolated scientific centres, such as one may hope will be founded in increasing numbers by the plantation industries in the overseas parts of the Empire.

ADVANTAGES OF MILK RECORDING.*

The advantages to be derived from keeping accurate records of the milk yields of cows have been urged repeatedly for many years, but such advantages are not yet as fully appreciated or as readily recognized as they might be, and although the Milk Recording Scheme of the Ministry has now been in existence for ten years there is still considerable apathy on the part of the British dairy farmer. Before the inauguration of this scheme in 1924 as part of the general scheme for the improvement of the live-stock of the country, milk recording in England was mainly confined to the owners of pedigree herds and to agricultural colleges and other educational institutions. During the last ten years, however, the movement has grown continuously and very considerable progress has been made. At the same time it must be admitted that the work is still in its infancy and that there is ample scope for extension of the practice. The number of cows and heifers in milk or in calf in England and Wales is, in round figures, 2,615,000, and of these only about 115,000, *i.e.*, less than 5 per cent, are being officially recorded.

In Denmark and other countries a thorough investigation has been made into the question of cost in the production of milk and its products, and it is now recognized that the taking of accurate records of milk yield, of individual butter fat tests and the examination of rations form the basis of any such investigation with a view to determine where cost may be reduced and production economically increased.

Selection of good milkers.

The first lesson to be learnt from the practice of keeping milk records is that of *selection.*

Economy in production is in the first instance attained by selecting the right animals, *viz.*, those giving a high yield of milk, provided they are of sound constitution. Every farmer is aware that there are good and bad milkers, differing comparatively little in their cost for keep and attendance, yet varying in milk yield from 400 to 1,000 gallons in a lactation period. The low-yielding cows in the herd certainly do not pay for their keep. These mere " pensioners " on the farm should obviously be fattened and sold, but first they must be identified, and the only sure means of identifying them is to keep records. Some cows give a large daily yield of milk for a short period only after calving, while others give moderate daily yields over a long lactation period, and it is impossible to estimate accurately the total yields of either class by mere observation. Even some of the most experienced judges of

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* Reprinted from *Jour. Min. Agri.*, XXXI, No. 10.

dairy stock have erred in calculations by as much as 200 gallons in their estimates of the yield of individual cows. Only by weighing the milk daily or weekly can the milk yield of each cow be ascertained. The record provides exact figures as to the producing power of each, thus indicating which should be disposed of and which retained. The following is a striking example of the great difference which exists between herds in their milk-producing value. Two members of the same milk recording society had 42 cows each. All were recorded for the full year. The average yield of the 42 cows in one herd was 889 gallons ; that of the other was 372 gallons. The approximate difference in the total yield was 21,700 gallons, which at 1s. per gallon represents a difference of £1,085 in the gross receipts for the same number of cows.

Breeding.

Having discovered the right cows to keep, the next problem to solve is the grading up of the herd. This can be done by rearing one's own heifer calves from the best milkers that have been sired by a bull of good pedigree milking strain, and always keeping in view the fact that good conformation and constitution are essential for success. Milk records form the starting-point for choosing the cows whose calves it will pay to rear, and even if the farmer does not rear his own heifer calves he will find that those from officially recorded dams will command higher prices than those which have no records behind them.

Rationing.

The keeping of milk records also forms the necessary basis for the scientific rationing of cows from the point of view of economical production of milk. When it is borne in mind that the cost of feeding cows, taken all the year round, accounts for probably no less than two-thirds of the total cost of milk production, the importance of this subject can hardly be overestimated.

The first principle of economical feeding of dairy cows is to ascertain, by carefully kept records, how much milk each cow is giving and to regulate the quantity and nature of her food accordingly.

Education.

Apart altogether from financial considerations, the work of milk recording is interesting and educational to the farmer and his employees. By a study of the records any slight reduction in yield will be noticed and the cause can be investigated. If the cause is sickness, improper feeding, exposure or neglect, the necessity of a remedy is brought immediately to the owner's attention. One of the first symptoms of ill-health in a cow is a decrease in the yield of milk, this often appearing before outward signs are visible, and a serious illness can thus often be checked in time.

Milk recording should encourage more efficient milking and more careful feeding, and where the owner is a member of a milk recording society he becomes associated with the progressive dairy farmers of his district, for their common benefit and good fellowship, and for friendly rivalry, besides getting into touch with some of the scientific problems which are continually arising in the practice of farming.

Private recording.

There are, of course, farmers who prefer to record privately rather than officially, and their records are no less accurate on that account. These farmers certainly have all the particulars they require for their own information, but their records do not possess the same commercial value when they wish to sell dairy stock or its progeny. Purchasers, and especially those from abroad, naturally show a marked preference for officially checked records, rather than for privately kept records, the acceptance of which usually depends on personal knowledge and appreciation of the herd-owner.

Again there are some farmers recording privately who maintain that their records are sufficient for the reason that they do not rear calves. Such owners are usually overlooking the possibility that one of their cows may prove to be of outstanding merit, a regular breeder and a consistent " thousand-galloner." Calves from such a cow would clearly be worth rearing to sell at the greatly enhanced value which they would acquire from the official milk record of their dam.

Expense of recording.

Another type of herd-owner refrains from recording on the ground of expense. Such expense in the case of a herd of 20 cows belonging to a member of a typical milk recording society is as follows :—(1) An annual subscription of, say, £1 1*s*., irrespective of the size of his herd, and (2) a yearly levy at the rate of, say, 4*s*. per cow ; total £5 1*s*., or less than $1\frac{1}{4}$*d*. per week per cow. In return for this modest outlay he reaps the following substantial benefits :—

(1) The records of his entire herd are checked in a thoroughly reliable manner which ensures that they will be generally accepted as statements of fact.

(2) Cows and their progeny vary in value in proportion to their records, and prices of deep-milking stock with authenticated records are likely to remain firmer than those of non-recorded stock.

(3) He is provided with a reliable guide as regards the elimination of unsatisfactory animals and the selection of animals from which to breed, and a most useful index to the health of his cows and the efficiency of his feeding system.

(4) His cows are marked and registered for permanent record (and his calves also, if he so desires, at a nominal cost).

(5) All the necessary books, forms, etc., are provided without cost to himself. Beyond his subscription and levy he has no further liability except for purely optional subsidiary services such as butter-fat tests, special visits, etc.

The following instance of the marked advance in the average yield of individual herds as a direct result of the more systematic and economic management arising from the adoption of milk recording is of interest: In the returns for 33 of the herds (of over 20 cows) of a certain society recording under the Ministry's milk recording scheme, which were recorded from 1917-18 to 1922-23, there was an average increase in the yield per cow of full-year cows of 92 gallons. The maximum increase shown by a herd was 234 gallons per cow, namely, from 524 to 758 gallons.

The dairy farmer must constantly be studying the problem as to how the cost of production can be reduced, and the herd managed if he is to make his business a paying proposition. The solution of the problem can be assisted by pursuing a policy of careful selection, breeding and scientific feeding; in other words, by successful management the key to which is undoubtedly the keeping of milk records.

FLOWERING, FRUIT-FORMATION AND DEHISCENCE OF THE BOLLS OF THE COTTON PLANT.*

BY

G. S. ZAITZEV.

[The Indian Central Cotton Committee are indebted to Dr. G. S. Zaitzev for the following account of some of the work at the Turkestan Plant Breeding Station at Tashkent. The transactions of the Station are published mainly in Russian, and it is hoped to publish a translation of the detailed work in a subsequent issue of the " Agricultural Journal of India ".]

THE vegetative period being in Turkestan comparatively short, it is of exceptional importance for a rich yield of the different sorts of cotton that they should ripen early. Early maturity is determined on one side by the time when the bolls begin to dehisce, on the other by the time when flowering begins. The advent of the latter phase settles the former, as between the period from sowing to flowering and the period from sowing to maturity (dehiscence of the bolls) there exists a direct, almost complete, correlation ; thus the coefficient of the correlation (r), according to the data of the author, for the indicated relation has proved to be +0·875. Having determined for a number of forms of cotton plants the time of the beginning of their bloom and of the dehiscence of their bolls, it will be observed that the shorter is the time elapsed from sowing to flowering the shorter also is the time from flowering to the dehiscence of the bolls ; a protraction of the first period is followed by a protraction of the second too.

The development of the individual cotton plant, the appearance of leaves and branches (sympodial ones), of buds on them, the opening of the flowers, the process of fruit-formation and of the dehiscence of the bolls, etc., are subject to certain regularities which in short may be summed up as follows.

For the first, or spring stages of the seedling (appearance of the leaves, formation of the branches, etc.) a comparatively slow progress of development is characteristic ; further on it accelerates until it reaches a certain constant. Towards fall again there may be observed a certain slowing down in the development.

The appearance of the buds (with the development of the branches and their parts) and afterwards the opening of the flowers proceed in a definite order which is similar for both ; therefore it will be sufficient to characterize the process of flowering, which in its simplest form is going on in the following way ; flowering begins

* Extract from *Trans. of the Turkestan Plant Breeding Station, Tashkent*, No. 1.

with the first flower of the first sympodium ; after 2-3 days the first flower of the second sympodium begins blossoming, then after the same interval of time, opens the first flower of the third sympodium, and so on ; thus a succession is produced, proceeding from bottom to top (at intervals of 2-3 days), which the author terms a short succession. At the moment when the first flower of the fourth sympodium begins to blossom (at times somewhat differently) the second flower of the first sympodium opens, thus beginning a new series of short successions for the second flowers of the sympodial branches. The second flower of the first sympodium opens 5-7 days after the first, the third opens after an equal interval, and so on. This rule is on the whole true for the succession of flowering along all the branches ; here (along the branches) a long succession is observed. If we were to calculate the ratio of the long successions to the short ones for any period of flowering, this ratio would prove to be 3,0 or 2,5. In the first case there is a coincidence of time for the blooming of the flowers with a distance between them of three branches, *i.e.*, in analogy with the coincidence along the vertical line of the branches arranged at 1/3 (as is the case with the cotton plant) ; in the second case there is a coincidence in the time of flowering for the flowers with a distance between them of five branches, *i.e.*, analogous to the coincidence along the vertical line of the branches arranged at 2/5 (as it is also the case with the cotton plant). By the relation of the successions and by the indicated coincidences (within their limits) the entire progress of flowering for the whole plant is determined. The first period of flowering (5-7 days) embraces the flowering of the first cone, which consists of three flowers (the first flowers of the three first sympodia) ; the second period (also 5-7 days) embraces the second cone of flowering, consisting of six flowers (the first flowers of the 4, 5 and 6 sympodia and the second flowers of the three first sympodia) ; the third cone of flowering includes nine branches, giving nine flowers ; the fourth gives twelve flowers, and so on. Such a progress of flowering, with coincidences analogous to the branching at 1/3, at a certain moment may be summed up by the formula 1,5 m. (m+1), where " m " expresses the number of layers (of three branches each) where flowering is over already ; in short, having counted, from the bottom to the uppermost, the number of sympodia on which the first flower is blossoming, and having ascertained the number of layers (by dividing the number of branches into three) we get, according to the above mentioned formula, the total sum of flowers blooming and having ceased to bloom at a chosen moment. For a progress of flowering with coincidences analogous to the branching at 2/5 the general formula, expressing the total of flowering, accordingly will be—1,8 m. (m+1). These two formulæ, like boundary-lines, are tracing the whole progress of flowering of the cotton plant with all its fluctuations. For the sake of greater intensity of the subsequent process of fruit-formation, which partly also determines early maturity, it is most desirable that the flowering of the cotton plant should proceed in the way characterized by the second formula. Both formulæ quite clearly show the advantage the early flowering forms are getting. Let us illustrate the proposition by an example :

The delay in flowering of the later plant by one cone gives to the earlier one an advantage of three flowers at first; afterwards, at the moment when, for instance, the eighth cone is flowering, the early plant is already at an advantage of 24—29 flowers.

A complicating circumstance in the progress of flowering is a certain slowing down of its rate towards autumn, but the reduction, being general for the whole plant, does not impair the correlations which we have pointed out and summed up in formulæ.

Additional flowers, arising sometimes near the principal ones, are behind those later in their bloom by two long successions.

The time when flowering sets in (as well as the time of ripening) is considerably fluctuating for the same form in connection with the particular year.

A special experiment has shown that ten hours after pollination but one-half of the pollen tubes (the more active ones) have had the time to pass through the whole length of the style (17 mm.). A complete shading of the flower before its opening, while it is opening, or after it has opened, involves a depression in the development of the fruit; the earlier the shading has taken place the stronger is the depression which shows itself in the reduction of the number of seeds formed, the weight of those latter and that of their embryos, and also in the reduction of the length of the fibre.

The rate of shedding of the bolls is less for earlier flowers, being on the contrary greater for late ones. The percentage of shedding of the bolls is determined by the position of those latter. The higher the branch the greater, on an average, is the percentage of shedding; the farther the boll is situated along the length of the branch, the less are its chances of developing into a fruit; thus, the shedding of the bolls is increasing in the direction from bottom to top, and from the centre (the main stem) laterally, along the branches; this later direction is characterized by a greater increase in the rate of shedding than the first one. The examination of the shedding of the bolls within the limits of some cone of flowering, *i.e.*, for the flowers belonging to one period of flowering, shows that in every such cone the percentage of shedding increases in the direction from the upper flowers to the lower ones. This tendency agrees well with the lengthwise development of the separate internodes of the sympod al branches. The length of the internodes invariably decreases towards the end of the branch while at the same time, within the limits of the cone, it increases from bottom to top. Thus the conclusion lies very near that the shedding of the bolls is in close connection with their nutrition. This difference in the nutrition of the separate bolls, in dependence on their position, tells not only on the rate of shedding but also on the number of seeds, developed in the bolls, and on their average weight. The difference in this respect is especially marked when the flowers are pollinated artificially. Artificial self-pollination in general augments the percentage of fruit-formation (*i.e.*, it reduces the rate of shedding of the bolls by 20 per cent.) as well as the number of seeds formed within the fruits, but it reduces the

average weight of those seeds. The above stated accentuates the fact that a fixed store of food is distributed among a greater number of consumers. On artificially self-pollinated bolls it becomes especially prominent that the number of seeds within a locule of the boll, as well as the average weight of the seeds are markedly diminishing towards the end of the branch ; the same decrease manifests itself in the direction from bottom to top. This leads us to the conclusion that the gradual increase of shedding of the bolls, within the limits of the plant, is in close connection with the diminished nutrition of the remoter parts of the plant. This progressive shedding is inevitable under any conditions of cultivation ; it may set in sooner or later and attain a higher or lower degree in dependence on the conditions of nutrition of the plant as a whole, which is not in contradiction with the discordant conclusions of Balls, Lloyd, and others, but reconciles them. A difference in the shedding of the capsules, in dependence on the position of the flowers on the panicle, can be observed on such plants as millet and rice. With hybrid forms of cotton the shedding of the bolls often depends on the abortiveness of the pollen in connection with the tabescence of the anthers.

Natural crossing, under the conditions of Turkestan, on an average, approximates 5 per cent., notwithstanding the great part insects are playing in the transference of the pollen. A certain reduction of natural crossing may be connected with the greater receptiveness of the cotton flower to its own pollen than to alien one. Special experiments with mixed pollination have clearly shown the superiority of the own pollen in regard to a more rapid fertilization of the ovules. The more genetically distant the form, the more it is at a disadvantage in the competition with the proper pollen of the respective flower. In the observed natural crossing the length of the style and stigma is of no essential importance and a short style does not prevent natural crossing.

The dehiscence of the bolls occurs in connection with the drying up and shrinking of the fleshy tissue of the outer walls ; a reduced contraction of this tissue (through artificial incisions, or through a natural feeble development) leads to a feeble dehiscence of the boll or the latter may not dehisce at all. Sun-heat, a strong illumination of the boll favour a more rapid dehiscence. This last circumstance somewhat disturbs the regular course of the process of dehiscence which, however, in its final results well adapts itself to the regularity we have pointed out for the flowering. In the period of flowering to the dehiscence of the bolls, within the limits of the plants, delays are observed which are increasing for the flowers situated at a greater distance along the branches, as well as for the flowers of the higher branches. In the period of ripening those delays, observed for separate bolls in dependence of their position, are analogous to the delays observed in general for the separate later forms of cotton. For all forms of the cotton plant, differing in the earliness of maturity, exists a definite correspondence between the period from sowing to flowering and that from flowering to the dehiscence of the bolls. With normal spring sowing in Turkestan, all forms of cotton show a correlation of those periods, expressed

in days, as 40 x : 60 x ; here " x " is the variable magnitude characteristic of every form of cotton in dependence on its early maturity. The existence of this correlation enables us to foretell the time of the dehiscence of the bolls of the cotton plant, by observing the time of its flowering. Besides, this correlation shows that the later the respective form begins to flower the longer will be the period from flowering to the ripening of the bolls. Within the limits of separate cones of flowering, it is observed that the bolls situated on higher branches are ripening more rapidly than those on the lower branches which is possibly in connection with the better nutrition of the higher bolls in the cone and their stronger illumination.

For summing up the process of dehiscence of the bolls with a feeble shedding, the same formulæ may be applied as given for summing up the process of flowering.

In order to calculate more precisely the comparative earliness of the separate forms of cotton it will be useful to determine the flowering and the dehiscence of the bolls confined to a certain layer of sympodial branches.

A Hybrid between Asiatic and American Cotton Plants—Gossypium herbaceum L. and Gossypium hirsutum L.*

ALL attempts of crossing Asiatic cotton plants with American ones, to begin with Trevor Klarke (in the seventies of the 19th century) up to our days, have invariably proved failures, with the single exception of the experiment of Gammie, who was successful in obtaining a hybrid between *Gossypium arboreum* L. var. *rosea* Watt (sort Varadi) and *Gos. hirsutum* L. (sort Dharwar). But this exceptional success has not altered the already established opinion that the Asiatic species of cotton are not to be crossed with the American ones.

The investigations of A. G. Niklojeva, founded on our material, have shown that the Asiatic species of cotton (*Gos. herbaceum*, *Gos. Nanking*, *Gos. obtusifolium*) widely differ from the American ones (*Gos. punctatum*, *Gos. hirsutum*, *Gos. mexicanum*, *Gos. barbadense*) by their number of chromosomes : the sommatic cells of cotton plants, belonging to the first, or Asiatic, group contain 26 chromosomes, while in the whole American group the number of those latter amounts to 52. This fact emphasizes the genetic remoteness of the aforesaid groups of cotton plants.

Some observations of the author on the cotton flower have led to the conclusion that an experiment, carried out under certain conditions, may result in the production of a hybrid between Asiatic and American species, notwithstanding their great genetic remoteness and all failures previously obtained. Those observations may be summed up as follows :—

(*a*) The alien pollen-tube (of another species or variety) grows more slowly in the tissue of a strange flower than its own one, and the more

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*Extract from *Trans. of the Turkestan Plant Breeding Station, Tashkent*, No. 2.

genetically distant the forms are, the more the growth will be retarded ;

(*b*) under natural conditions the cotton flower is receptive to pollen only during one day, for on the next day, owing to the continued growth of the ovary and the stopping of growth of the corolla, the style is ruptured by the sliding down corolla and falls off together with this latter afterwards. A complete exposure of the pistil by means of removing the whole corolla makes it receptive to pollination also on the second day.

Thus we may consider that it is the premature rupture of the style on one side and the too much delayed growth of the pollen-tube on the other which prevent the production of hybrid seeds.

Proceeding from the above mentioned premises, there were in 1921 once more carried on on a large scale experiments of crossing between Asiatic and American forms of cotton plants. Those experiments took place at the Plant-Breeding Station in Turkestan ; a new method of castration was applied, the pistil being completely exposed by means of removing the whole corolla, together with the stamen tube. The result obtained by this crossing was a hybrid between *Gos. herbaceum* L. (Bucharskaja Gusa) and *Gos. hirsutum* L. var. *laciniata* m. (v, nova). The female parent represented the usual type of *Gos. harbaceum* L., with a 4-5 locular boll, feebly dehiscent, with yellow speckled flowers and closely united bracts. The male parent represented the typical form of " Upland," which the author, however, separates into a distinct variety-- var. *laciniata* --owing to the shape of its strongly parted leaf (of the type " okra leaf "). The difference of this shape of leaf from the usual one is conditioned, as the investigations of the author have shown, by the difference of only one gen.

The species hybrid thus obtained, by the majority of its characters, was occupying an intermediate position between its parents, though several of the characters exhibited by the parents did not appear at all ; thus the dense cover of short hairs shown by the female parent was completely absent ; there was no irregularity in the shape of the petals, a characteristic feature of the female parent. Thus the male parent appeared to be dominant. Besides, an intensification of characters was showing itself ; the long hairs of the hybrid were more densely arranged than those of the original parental form ; also the length of the hairs themselves was greater. An especially strong intensification was displayed in the growth of the plant ; without essentially diverging from the general character of the habitus, the hybrid produced as if a twice magnified copy of the habitus average for both parents, thus exhibiting a strongly marked gigantism.

The obtained species hybrid produced during the season of 1922 over 500 flowers, but without giving as much as a single fruit ; all the ovaries invariably fell off soon after flowering (after 4-5 days). Pollination of the flowers of the hybrid with pollen

of the parents, as well as with pollen of other forms of cotton plants (the species *Gos. barbadense, Gos. hirsutum, Gos. herbaceum, Gos. Nanking,* and others) did not lead to fructification either. The transference of pollen of the hybrid on above mentioned forms also had a negative result. Thus the hybrid has proved sterile. Its complete sterility is due on one side to the pollen remaining not fully developed, on the other side, possibly to the not quite developed ovules. In order to continue during a second year the observations on the hybrid, this latter is preserved alive till next season—1923.

TWO VALUABLE FODDER TREES.*

BY

C. T. WHITE, F.L.S.,

Government Botanist, Queensland.

I HAVE long been of the opinion that one of the surest ways to combat the serious droughts, that Queensland in conjunction with most other parts of Australia periodically suffers, is by the systematic planting of drought-resistant fodder trees. Trees, owing to their extensive and usually deep root systems, once established have an advantage as drought resisters over grasses and herbage. Two trees commonly planted in Queensland gardens as shade trees have been brought under my notice recently as trees of considerable value as food for stock.

One of these trees is the Phytolacca or Bella Sombra tree (*Phytolacca dioica*) and the other the mis-called " Portuguese Elm " (*Celtis sinensis*).

PHYTOLACCA OR BELLA SOMBRA TREE (*Phytolacca dioica*).

Description. A large rapid-growing soft-wooded tree ; leaves a rather bright glossy green, long-stalked, the stalk often purplish, lamina or blade of leaf usually oblique at the base, *i.e.*, one side longer than the other. Flowers greenish white in long slender racemes (" spikes ") of six to nine inches or even longer, the male and female flowers on distinct trees. Fruits densely clustered along the spikes, depressed globular.

Native country. A native of South America ; widely cultivated in the subtropics as a shade tree.

Botanical name. From the Greek *phyton*, a plant, and the Italian *lacca*, lac or varnish ; from the berries or fruit of some species yielding a red colour like lac.

Fodder value. In his " Comprehensive Catalogue of Queensland Plants " the late F. M. Bailey remarks, " Cows will devour the stem of this tree when cut down as they do our Bottle tree." This, however, is a very wasteful method of utilizing a very valuable fodder tree, and I was, therefore, glad to hear recently from my friend Professor S. B. J. Skertchly of the use of this tree as a fodder at Purga, near Ipswich. I later visited the farm of Mr. Dick at Purga, and he . . . . kindly gave the following particulars regarding the methods of using this tree as a fodder. Mr. Dick stated : "As Queenslanders know, nine out of every ten springs come in

* Reprinted from *Queensland Agricultural Journal*, XXII, 5.

dry, and our way of helping the calves over the spring is to prune the Phytolacca trees of a few branches every day. These branches are anything up to 12 feet long (one year's growth). Whether dry or not we always prune in the spring to have a strong crop of shoots next year. One cannot grasp the effect of the prunning unless seen. I may say we have known a single shoot of one year's growth to be 4 inches across at the butt, to attain 16 feet in length, and to weigh 28 lb. ; of course cattle would not eat all of such a big shoot as this, but would eat all the leaves and chew the stem down to about where it was 2 inches thick. These trees make very rapid growth here. A number of young underhanging shoots are always left to bear flowers and fruits."

As stated by Mr. Dick the tree is a rapid grower. Two years after planting, the tree is about 12 feet high, and measures 1 foot 5 inches in girth 3 feet from the ground and 2 feet 4 inches in girth at the base. A tree planted in 1901 has at the present time a girth of 8 feet 9 inches at about 3 feet from the ground.

From the above it will be seen that the Phytolacca is a very valuable tree for planting in Queensland as a fodder.

NETTLE ELM, MIS-CALLED "PORTUGUESE ELM" (*Celtis sinensis*).

Description A deciduous leafy tree not usually very tall and with a large spreading head. Leaves glossy green above, somewhat paler beneath, the base usually but not always very oblique (*i.e.*, lopsided), mostly $1\frac{1}{2}$-2 inches long and 1 to $1\frac{1}{2}$ inches broad, borne on a stalk of about one-third of an inch. The edge bluntly toothed in the upper part of the leaf. Flowers insignificant. The fruits are small rounded drupes (berries) borne on slender stalks of about one-quarter of an inch long in the axils of the leaves, yellow when ripe and about one-quarter of an inch in diameter.

Native country. China ; a widely spread tree in the Orient.

Fodder value. Our attention was first drawn to this tree as a fodder by Mr. E. Everett, Inspector of State Advances Corporation at Gayndah, who, in a letter dated 31st December, 1923, wrote :—

"I would like to draw attention to a splendid fodder tree which grows along the banks of the river at Gayndah and in some instances is used as an ornamental tree. I have been told that the name of the tree is 'Portuguese Elm.' It sheds its leaves annually but has a most luxuriant growth of leaves from about October to June, and if these trees were planted along the river and creek banks there would never be any occasion to lose a beast from starvation during those months in the most severe drought. The trees are hardy but of course require protection until they grow out of reach of horses and cattle. Small trees can be got by thousands under the trees, but cattle and horses never let them grow high when within their reach. I have had experience with Currajong, Oak, and Bottle-tree, which will keep cattle alive for a little while, but they will thrive and improve on Portuguese Elm. If

any officer of the Agricultural Department passes through Gayndah at any time I should much like to show him these trees and give him any information I possess on the matter."

The point brought forward by Mr. Everett is a very important one, and I fully endorse his opinion that the planting of fodder trees would in the end go a long way to mitigating the losses of stock that occur during every drought period.

Celtis australis is another species that is grown in Queensland gardens but to a less extent than *C. sinensis*. Of *C. australis* Sir George Watt, in his "Dictionary of Economic Products of India," says, "The tree is largely planted for fodder, cows fed on the leaves are supposed to give better milk." This species would no doubt stand greater degrees of cold than *C. sinensis* and would be a valuable tree for the Darling Downs, where some fine trees are already to be found.

Botanical name. *Celtis*, one of the names anciently given to the Lotus. Tounefort first applied the name to the modern genus which may be said to resemble both in the fruit and foliage the shrubby Lotus of the ancients (Loudon, Dictionary of Plants); *sinensis*, a native of China, from the Latin *Sinæ*, an Oriental people.

Common name. Though the tree is a native of China, in Queensland the tree is known almost everywhere under the name of "Portuguese Elm." This arose, no doubt, from its confusion with another species of *Celtis* (*C. australis*) cultivated in the cooler parts of the State, and a native of Southern Europe.

Identification of the tree. The present tree is common in Queensland gardens and has variously passed as *Celtis australis*, *C. Krausiana*, and *C. occidentalis*, but as I could not fit it in with any of these species, I sent specimens to the Director, Arnold Arboretum, Boston, U. S. A., and obtained the reply that the tree was *C. sinensis*, a native of China, and widely spread in the Orient.

NOTES

CROSSING OF SMALL GRAINS MADE EASY.

Hybridization work comes in at some stage or other in the course of crop improvement. In the case of big flowers emasculation and crossing is easy, but with minute flowers of grasses and cereals especially, the technique of crossing is a very elaborate and delicate process. The flowers are so minute that it is difficult to manipulate them. The artificial forcing open often results in a permanent unhinging of the glumes and results in consequent unsetting. As one handling minute-flowered millets, the writer read with not a little welcomeness the most interesting record by Mr. V. K. Badami, Senior Assistant Botanist, in the current Mysore Annual Reports, of a method of handling the flowers of one of the millets—*ragi* (*Eleusine coracana*). Any one studying the opening of cereals will notice that certain sets of external conditions determine the opening of the glume and the bursting of the anthers. They are finely modulated in nature, but relatively speaking the factors for glume opening may be termed gross, in contrast to those at work determining the opening of the more delicate anthers. It is a perception of the nice differentiation between these two sets of factors producing the two independent phenomena, that is at the bottom of this discovery. *Ragi* flowers usually open with the anthers opening simultaneously. Wide test tubes or small flasks lined with moist filter paper were inverted over the flower and plugged with absorbent cotton and the pollen sacs came out intact. Verily may the author claim that a new method has been struck at, making hybridization work easy. What is required is an intense and careful study of the factors at work in the opening of a flower, a differentiation between glume opening and anther opening factors and an artificial simulation of the former set of conditions with a view to a premature ejection of the intact anthers, which are then easily removed off with a pair of fine forceps. This is emasculation in excelsis. The normal flower opening period is watched for the pollen gathering and the stigma dusted at the right receptive time. The method of handling will vary with different sets of flowers—radically varying in such day-opening flowers as rice and *samai* (*Panicum miliare*) and such essentially night-opening flowers like *cholam* (*Sorghum vulgare*). [G. N. Rangaswami Ayyangar.]

PRODUCTION OF REFINED SUGAR BY MODERN REFINERIES IN INDIA DURING THE SEASONS 1923-24 AND 1922-23.

Out of the 25 refineries in India, 22 worked during the season 1923-24 as compared with 18 in the previous season. Out of these 22 refineries, 11 are situated in the

United Provinces, 6 in Bihar and Orissa, 4 in Madras and 1 in the Punjab. As mentioned by me in my previous note, this increase in number was due to two cane crushing factories having equipped themselves with the necessary plant for refining *gur*, one which had gone into liquidation having re-started work, while one more refinery opened its first campaign during the year under report.

We give below figures of *gur* melted and sugar obtained therefrom in the refineries situated in Northern India and Southern India separately, and also consolidated figures for the whole of India, during the two seasons 1923-24 and 1922-23.

	1922-23	1923-24
Northern India—	Maunds	Maunds
Gur melted	1,884,332	2,281,187
Sugar made	993,599	1,073,788
Southern India—		
Gur melted	651,771	979,746
Sugar made	374,527	466,623
Whole of India—		
Gur melted	2,536,103	3,260,933
Sugar made	1,368,126	1,540,411
Molasses obtained	858,473	1,193,692

It will be seen from the above that there was an increase in the quantity of *gur* melted and sugar made in all the important provinces of India, mostly due to the fact that large quantities of *gur* were available for refining as the result of an increased production of *gur* during the crushing season 1923-24 and the consequent low prices prevailing for this commodity.

A note published in the January (1925) No. of this Journal gives the total quantity of sugar produced by factories making sugar direct from cane for the two seasons 1923-24 and 1922-23 as follows :—

	Maunds
1923-24	1,044,855
1922-23	651,415

If the quantity of refined sugar produced in India by modern refineries be added to these figures, the total production by modern factories and refineries would amount to 2,585,266 maunds or 94,796 tons as compared with 2,019,541 maunds or 74,052 tons in the previous season.

In the current season 1924-25, as the estimated production of *gur* in India is some 780,000 tons less than last year, and as the prices of *gur* are high while those of sugar are comparatively low, some of the refineries will not find it profitable to work, and hence there will be a fall in the production of refined sugar.

In conclusion, we have to express our obligations to the Managing Agents and Proprietors of various refineries for the readiness with which they furnished us with the statistics worked up in this note. It is satisfactory to note that returns were received from all refineries that worked during the season. and that these concerns also appreciate the importance of a compilation of such figures for India as a whole. [WYNNE SAYER.]

MORPHOLOGICAL FACTORS INFLUENCING YIELD IN INDIAN COTTON.

THE present writer (Prof. S. C. Harland) in 1918 showed that in a number of strains of Sea Island cotton a strong positive correlation existed between the weight of lint borne by a single seed and the yield of lint per acre.

The importance of the correlation between lint per seed, lint per plant and lint per acre is enormous from the point of view of the plant breeder, for it becomes an easy matter for him to increase yield merely by selecting for high weight of lint per seed. Due regard should of course be paid to the selection of strains resistant to shedding, and a desirable habit of growth should also be attended to in the course of selection.

A recent paper by Kottur presents data on certain of the characters of Indian cotton which have been shown to influence yielding power in Sea Island. and an analysis of his data will be instructive.

Kottur presents data on the varieties Kumpta and Dharwar No. 1, the spacing being 24″×18″.

	Flowers per plant	Bolls per plant	Bolls to flowers
1917-18			Per cent.
Dharwar No. 1	23	16	67
Kumpta	37	15	41
1918-19			
Dharwar No. 1	28	19	69
Kumpta	47	19	40

Other data which it is possible to obtain from Kottur's paper either directly or by calculation are placed below, together with a comparative set of data of the

heavy yielding strain Sea Island H 23, isolated in Montserrat by the late Mr. William Robson.

	Dharwar No. 1	Kumpta	H 23 Sea Island
Seed weight in mg.	55	52	136
Lint weight in mg.	22	18	59
Ginning percentage	28 5	25·5	30·4
Mean boll loculi	..	3 0	3·6
Ovules per loculus	..	6·5	..
Seed per boll	..	19 5	21·7
Lint per boll grm.	..	0·35	1·23
Seed cotton per boll grm.	..	1·36	4·23

It will be seen from the above that while the percentage of bolls to flowers is much greater in Dharwar than in Kumpta, the number of bolls per plant is approximately the same in the two strains in two successive seasons. The weight of lint per seed is, however, 22 per cent. greater in Dharwar. If the mean number of seeds per boll and number of bolls per plant are not materially different in the two types, the increased weight of lint per seed of Dharwar should reflect itself in an increased yield of lint per acre. Actually according to Kottur's figures the increase in yield of lint per acre has been roughly 35 per cent. Some of this increase is probably due to the greater weight of lint per seed of Dharwar. One would hardly wish to stress the point too far, but it is obvious that analyses of this kind are of the utmost value in selection for high yield, a weak point in a strain being instantly revealed [Extract from *Tropical Agri.*, II, No. 2.]

PRIZE THESIS OF THE PUNJAB BOARD OF ECONOMIC INQUIRY, RURAL SECTION.

We have received the following for publication :—

In order to encourage post-graduate study and research into the problems of village economics, the Board of Economic Inquiry, Punjab, has decided to offer a Prize of Rs. 750 for the best report drawn up on the lines indicated in the questionnaire for economic inquiries. (Obtainable from the Civil and Military Gazette Press : price Annas 6, postage extra.)

The Prize will be open for competition among graduates of the Punjab University.

The village selected for inquiry must be in the province of the Punjab.

The Board reserves the right to withhold, divide or supplement the Prize as it may see fit.

Award will be made only where the report is considered by the Board to be worthy of publication as an original contribution to the economic knowledge of the province ; and in making an award the Board may lay down such conditions regarding publication as it sees fit. The copyright of all reports for which award is given shall vest in the Board.

The decision of the Board on all matters relating to this contest shall be final.

Two typed copies of the report must be lodged on or before 30th April, 1926, with the Honorary Secretary, Board of Economic Inquiry, Punjab, Rural Section, University Hall, Lahore.

Candidates are advised to submit the name of the village selected for approval by the President.

COTTON NOTES.

Through the courtesy of the British Cotton Industry Research Association, the Secretary of the Indian Central Committee has sent the following abstracts for publication :—

Factors affecting Length of Cotton Hair.

To elucidate the common belief that in long-staple cotton the first pickings are shorter than later ones measurements have been made of the length of the hairs on one seed from a ripe boll from each successive fruiting branch on ten well-grown plants of Pima cotton grown under irrigation in Arizona. It is concluded that bolls borne on the lower fruiting branches, constituting the so-called "bottom crop," produce shorter fibre than bolls that are situated higher on the plant. Measurements were also made to ascertain whether there is a consistent relation between hair length and date of opening of the flower from which the bol developed. The data obtained were insufficient to make generalization safe but the results point to the conclusion that hair length is affected less by the date of flowering than by the height on the plant of the fruiting branch on which the boll is borne. [*Jour Agri. Res.*, 1924, **28,** 563-565. T. H. Kearney.]

Treatment of seeds with Uspulun and Germisan.

Uspulun, manufactured by the Bayer Co , is stated to contain as its active principle a mercury derivative of chlorophenol. Germisan is a similar organo-mercurial compound, manufactured by the Saccharin-Fabrik, A. G. vorm. Fahlberg, List & Co. Both compounds have given remarkable results on the Continent in the treatment

of seed diseases. Diseases of seeds that are at all amenable to chemical treatment are eradicated completely, and germination of the seed is actually promoted. The cost per pound weight compared with that of copper sulphate or formaldehyde is high but it is claimed that the increased yield more than repays the additional outlay. [*Chem. Age*, 1924, **11**, 465. M. BRISCOE.]

COTTON CULTIVATION IN AUSTRALIA.

The Murray and Murrumbidgee river areas have a climate similar to that of Russian-Turkestan, and for successful development under irrigation an early maturing variety of cotton is essential. In Western Australia the prohibiting factors are lack of population, communications and marketing organization. The soil conditions in the 200 miles strip along the coast of N. Territory are mostly unsuitable, and other parts, *e.g.*, the upper reaches of the Roper river where black labour is plentiful and fairly efficient are too remote for early white settlement. The coast margin of New S. Wales has probably too much rain and is too humid in the picking season for successful cotton growing ; but these unfavourable conditions disappear 15 to 20 miles inland and the middle and upper reaches of the valleys are very suitable. On the western side of the Main Range the season is short and early ripening varieties will give the best results. Parts of Queensland are generally too wet and the plant tends to put on too much wood in these areas ; while some diseases, notably boll-rot, are encouraged by humidity and cause considerable damage in the coastal belt. Generally a belt between the New South Wales border and Mackay is the most suitable. If all the farmers at present farming in Queensland would take up cotton growing, and with the existing scarcity of population and under mixed farming conditions, the limit to production would be 50,000 bales. [*Australian Cotton Grower*, 1924, **2**, No. 4, 21-27 ; and No. 5, 21-26. G. EVANS.]

The unusually cool spring and summer experienced in Murrumbidgee resulted in poor crops. Durango, a late maturing variety, yielded badly. Pima and Egyptian, because they are still later maturing than Durango, are the more unsuitable and growers accordingly are advised to use the Upland type. Farmers are warned to disregard the advice of those who would have them grow the longest staple varieties. Except under ideal conditions these types do not produce a characteristic crop and yield even shorter and poorer quality staple than that of the short-staple Upland grown in the same area. The use of superphosphates as an aid to maturing is urged. [*Australian Cotton Grower*, 1924, **2**, No. 5, 26-27. H. WENHOLZ.]

COTTON CULTIVATION IN DUTCH EAST INDIES.

Cotton growing is still in the early stages of development in spite of favourable early indications. Native production advances very slowly though the Government has distributed seed freely. Flores and Palembang are the chief areas : in the former Carravonica is grown. Unfavourable weather conditions seriously

injured the 1923 crop and only 213 tons of mature cotton and 292 tons of stained cotton were produced in Java. From the whole of the Dutch possessions, only 2,210 tons were available for export, most of which went to Japan. [*Leipzig. Wochenschr. Text. Ind.*, 1924, **39,** 954.]

Cotton Cultivation in Fiji.

The Sea Island crop of Fiji for last season amounted to 101 bales of 300 lb. each, and the price obtained at Liverpool was 11 *d.* over American f. a. q. cotton. [*Australian Cotton Grower*, 1924, **2,** No. 5, 6.]

On the leeward side of the Fiji Islands a production of 1,000 bales is considered possible. The type at present grown is Sea Island, but its substitution by a staple American type is under consideration, because of the limited market for Sea Island cotton. Perennial cultivation is prohibited on account of the pink boll-worm. Production is limited by scarcity of population. [*Australian Cotton Grower*, 1924, **2,** No. 7, 4. G. Evans.]

Cotton Cultivation in Guatemala.

The present crop is expected to yield 50,000 to 100,000 centals of seed cotton. Criollo, the native cotton, varies in length from $1\frac{1}{16}$ in. to $1\frac{1}{8}$ in. and is white and exceptionally strong in fibre, and the plant is practically disease-proof. Successful experiments with Allen long staple have yielded a staple of $1\frac{3}{16}$ in. and a ginning outturn of $31\frac{1}{2}$ per cent. To protect the industry the duty on imported raw material has been doubled. [*The Times Trade and Engineering Supplement*, 1st Nov., 1924, p. 142.]

Cotton Cultivation in Sudan.

Estimates for the 1924 crop indicate an approximate yield of 136,400 to 156,000 kantars of Sakel, and 35,000 to 36,000 kantars of American cotton. About half of each type is grown by the natives and half either under Governmental control, or by the Sudan Plantation Syndicate. Five to six thousand kantars of American are grown by the natives under rainfall conditions in the Gezira and Gedaref. [*Bull. Imperial Inst.*, 1924, **22,** 3, 341-347; from *Ann. Rep. Dir. Comm. Intell. Branch, Centr. Econ. Bd., Sudan Government.*]

Cotton Cultivation in Turkey (Cicilia).

The 1923 crop was 80,000 bales compared with 24,000 and 120,000 in 1922 and 1913 respectively. Arrangements have been made by the Turkish Government for the direct marketing of the Cicilia crop in Liverpool. [*Australian Cotton Grower*, 1924, **2,** No. 7, 5.]

COTTON CULTIVATION IN UGANDA.

An outline of the Government's policy with regard to cotton growing is given, and the intention of setting up a Cotton Control Board is announced. While last season's crop amounted to about 93,000 bales of 400 lb. the 1924 crop will exceed 125,000 bales. Of this the Menga and Busoga districts have produced 30,000 and 25,000 bales respectively, giving a yield of 532 lb. per acre as compared with 355 lb. per acre in the Eastern Province. These districts are expected shortly to rival Eastern Province in total yield ; and other promising districts are Bunyoro, Galu and the banks of the White Nile. [*Bull. Imp. Inst.*, 1924, **22**, No. 3, 358-360 ; from *The Uganda Official Gazette*, April 15th and May 28th, 1924.]

GRADING AND PRICES OF COTTON IN AUSTRALIA.

Commonwealth cotton grades and guaranteed prices for the season are :—Middling Fair, " A," 5¾ *d.* per lb. ; Strict Middling, Good " B," 5¼ *d.*; Good Middling, " C," 5 *d.*; Strict Middling and Middling, " D," 4¾ *d.*; Strict Low Middling and Low Middling, " E," 4½ *d.*; Strict Good Ordinary and Good Ordinary, " F," 4 *d.*; Strict Ordinary and Ordinary, " G," 3½ *d.* Immature Cotton :—In grades A. B. " 1.X", 4¾ *d.* ; in grades C. D. " 2.X", 4¼ *d.* ; in grades E. F. G., " 3.X," 3½ *d.* These are prices for seed cotton. [*Australian Cotton Grower*, 1924, **2**, No. 7, 7.]

VARIETY TESTS WITH COTTON IN AUSTRALIA.

Varietal tests at Mildura gave the following results in lb. of seed cotton per acre. Durango 528 ; Acala 801 ; Queensland Uplands 506 ; Durango (Wahgunyah seed) 700 ; Sunbeam 340 ; Webber 19, 410 ; Pima 210 ; Allen's Improved 524 ; Sakellaridis 36 ; Brown's 180 ; Hartsville 234 ; per acre. It is hoped to find a suitable short maturing variety and Acala is the most promising. [*Australian Cotton Grower*, 1924, **2**, No. 7, 17.]

COTTON INSECT PESTS IN AUSTRALIA.

An illustrated description of the bollworm, cut worms, lady-bird, aphis, four types of bugs, red spider and yellow beetle, with brief notes on their effects and control. More details are given concerning the green-stripped cotton moth (*Earias huegeli*) which is common in N. S. Wales, and a new pest, the cotton tip moth (*Eucosma plebeiana*). [*Australian Cotton Grower*, 1924, **2**, No. 4, 29-33 ; No. 5, 29-31. W. B. GURNEY.]

The most destructive and widespread cotton pests in Queensland are the maize grub (*Chloridea obsoleta*), the peach moth (*Dichocrocis punctiferalis*) and the Chinese or Harlequin bug. (The pink bollworm, so far, is only found in coastal areas.) Experimental stations have been created for the study of these pests and a brief outline of some of the methods of research is given. [*Australian Cotton Grower*, 1924, **2**, No. 5, 33-35. E. BALLARD.]

Effect of water on Cotton Plant in Egypt.

Experiments have been carried out for five consecutive seasons at Bahtim on the relation between water supply and its effect on the cotton plant. The particular variety was Sakellaridis. The results are as follows:—(*a*) *Flowering curve.* With light irrigations the flowering curve approaches closely to the theoretical form, namely, that of a plant grown under presumably ideal conditions. With heavy irrigations the deformation and the lateness of the curve are quite marked ; and the effect of nitrate fertilizing is to intensify the effect of abundant water supply. The conditions making for increased vegetative growth are those which produce a delay in flower appearance. (*b*) *Growth.* Heavier irrigations result in increased growth, longer internodes and more rapid development and the delay in the flowering curve cannot be correlated with delayed plant development. (*c*) *Shedding.* The higher shedding of squares from heavy waterings was distinct both in 1921 and 1922 ; and it is this shedding of buds that is the main reason for the lateness of flowering. (*d*) *Comparison of 1920 and 1921 experiments.* It appears to be quite significant that beyond a certain limit, abundant water supply, abundant plant food, and favourable climatic conditions for vegetative vigour are undesirable, from the point of view of crop production. These conditions make, however, for quality and size of boll, so that the actual crop differences are not so marked. In practice, lateness, such as is due to heavy irrigation, means a greater proportion of attack by the pink bollworm and very little cotton can be expected at Bahtim from flowers that bloom after the end of July. (*e*) *Mutual relations between growth, shedding and flowering.* All flowers were removed daily from 100 plants during the 1921 experiments and the treated plants produced almost exactly twice as many flowers as the untreated plants alongside. They also remained greener and became taller as the season advanced. It is thought that shedding normally acts as a safety device during unfavourable conditions, allowing the plant to rest until these conditions are passed. If, however, they are prolonged beyond a certain stage the final crop yield is bound to suffer. As far as the maturation period from flower to boll is concerned irrigation conditions have slight effect. In respect of these experiments, the methods employed in plot arrangement, water control and ordinary cultivations are given and detailed lists of growth readings and harvest records are provided. (*f*) *Topping.* In a further experiment it was found that the depressing effect on the later flowering period, by water restriction, was intensified by topping. [*Sultanic Agri. Soc. Tech. Sec. Bull.* No. 14, 63 pp. J. A. Prescott.]

Cotton spacing experiments in Egypt.

The general conclusions on the results of cotton spacing experiments show that the best practical conditions are those which permit of as wide a spacing as is possible consistent with yield. This makes not only for economy in seed but also for ease in cultivation and harvesting and frequently for quality. For a range of spacings

between 25 and 105 cm., the total number of flowers produced per fedden tends to a constant ; in the case of Sakellaridis about half a million. Wider spacing is compensated for by the prolonged flowering period of the larger plants, but after the first week in August the flowers produce bolls, which are all attacked by pink boll-worm with practically complete loss of this portion of the crop. It is this factor which accounts for the smaller yields at the wider spacings. At the closer spacings, fertilization resulted in increased vegetative vigour and in a corresponding increase in the number of flowers, whereas the unmanured close spaced plants showed signs of nitrogen starvation.

Shedding is increased considerably by wide spacing but larger bolls result. The maximum yield was obtained from a 35 cm. spacing with 30,400 plants per feddan. The yield per unit area, as expressed by the number of bolls, approaches constancy when the density of the planting is greater than 20,000 per feddan. At these closer plantings, however, the bolls are small and the actual yield by weight diminishes when plants are excessively crowded. [*Sultanic Agri. Soc. Tech. Sec. Bull.* No 13, 37-56, 63. J. A. PRESCOTT.]

RATOON COTTON REGULATIONS IN AUSTRALIA.

There are four types of plant cultivation and the danger ratio of these as pest carriers is in the reverse order in which they are stated below :—

Annual cotton, planted each season and ploughed out or burnt over each season. *Ratoon cotton* (in U. S. A., stump or sprout cotton), pruned down to 4 or 6 in. above ground at the end of the season. *Standover cotton* (in U. S. A. bolly cotton), cotton left over from year to year without pruning, or is grazed off. *Cruiser or windflown cotton* (in U. S. A. volunteer cotton), from windblown, dropped or scattered seed or bolls. Cruiser cotton should be destroyed, Standover cotton made illegal and Ratoon and Annual cotton regulated by law and license. The Queensland Government regulations, based on these considerations, are given. [*Australian Cotton Grower*, 1924, **2** No. 7, 18.]

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

MR. G. S. HENDERSON, N.D.A., N.D.D., Imperial Agriculturist, has been appointed to act as Joint Director, Agricultural Research Institute, Pusa, *vice* Dr. W. H. Harr son on leave.

DR. J. N. SEN, M.A., Ph.D., F.C.S., Supernumerary Agricultural Chemist, has been appointed to act as Imperial Agricultural Chemist, *vice* Dr. W. H. Harrison on leave.

MR. T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S., Imperial Entomologist, has been granted combined leave for 18 months from 27th April, 1925, Mr. M. Afzal Hussain officiating.

MR. R. S. FINLOW, B.Sc., F.I.C., Offg. Director of Agriculture, Bengal, has been confirmed in that appointment with effect from 17th February, 1925.

MR. P. H. RAMA REDDI, M.A., B.Sc., Deputy Director of Agriculture, III Circle, Madras, has been granted study leave for 12 months and leave on average pay for 6 months from or after 15th June, 1925.

MR. D. G. MUNRO, B.Sc., Deputy Director of Agriculture, Planting Districts, Madras, has been granted combined leave for nine months from or after 1st April, 1925.

RAO SAHEB M. R. RAMASWAMI SIVAN, B.A. Diploma in Agriculture, Government Lecturing Chemist, Agricultural College, Coimbatore, has been confirmed in the Indian Agricultural Service from 3rd March, 1925.

MR. P. T. SAUNDERS, M.R.C.V.S., Offg. Professor of Pathology and Bacteriology, Madras Veterinary College, has been confirmed in the Indian Veterinary Service.

MR. H. P. PARANJPYE, B.Ag., has been appointed to act as Horticulturist to Government, Bombay, *vice* Mr. G. S. Cheema on leave.

MR. C. A. MACLEAN, M.A., B.Sc., Deputy Director of Agriculture, North Bihar Range, has been granted leave on average pay for eight months from 19th February 1925, Mr. N. S. McGowan officiating.

CAPTAIN P. B. RILEY, M.R.C.V.S., Deputy Director, Civil Veterinary Department, North Bihar Range, has been granted leave on average pay for eight months from 29th March, 1925, Captain G. G. Howard officiating.

RAI SAHIB PRIYA NATH DAS has been appointed to hold charge of the Orissa Range with all the powers of a Deputy Director of the Civil Veterinary Department, *vice* Captain G. G. Howard on other duty.

DR. A. E. PARR, B.Sc., Ph.D., M.A., M.S., Deputy Director of Agriculture, Western Circle, U. P., has been granted leave on average pay for six months from or after 7th April, 1925.

MR. T. R. LOW, B.Sc., Deputy Director of Agriculture, Central Circle, U. P., has been granted leave on average pay for seven months from 6th April, 1925. Rai Sahib Nand Kishore will be in charge of the Central Circle during Mr. Low's absence.

BABU HARBHAJAN LAL has been placed in charge of the North-Eastern Circle, U. P., as Deputy Director of Agriculture from 13th March, 1925, *vice* Rai Sahib Ganga Prasad on leave.

Chaudhuri Muhammad Abdulla took over charge as Deputy Director of Agriculture at Lyallpur on 1st January, 1925.

Dr. P. E. Lander, M.A., D.Sc,, A.I.C., Agricultural Chemist to the Government of the Punjab, has been granted leave on average pay for eight months from 1st January, 1925.

Mr. J. Charlton, M.Sc., A.I.C., Principal, Agricultural College, Mandalay, has been granted leave on average pay for seven months from 1st March, 1925, Mr. M. McGibbon officiating.

U Po Shin has been placed in charge of the current duties of Agricultural Chemist, Burma, *vice* Mr. Charlton on leave.

Mr. D. Hendry, N.D.A., B.Sc., Deputy Director of Agriculture, Southern Circle, Burma, has been granted leave on average pay for eight months from 26th March, 1925, Mr. R. Watson officiating.

U Kyaw Zau, Assistant Director of Agriculture, has been placed in charge of the Arakan Circle, Burma, *vice* Mr. R. Watson on other duty.

Mr. H. F. Robertson, B.Sc., Deputy Director of Agriculture, Irrawady Circle, Burma, has been granted combined leave for eight months from 7th March, 1925. Mr. R. Beale will be in charge of the Circle during Mr. Robertson's absence.

Mr. A. McLean, B.Sc., Deputy Director of Agriculture, East Central Circle, Burma, has been granted combined leave for eight months from 11th March, 1925,

REVIEWS

Mr. Howard's book entitled "**Crop-Production in India**" published by the Oxford University Press at a cost of 10 *s.* 6 *d.*, or approximately Rs. 8, will meet a felt want in Indian agricultural colleges, as well as in universities which include agriculture in their curricula. During the last 20 years a considerable amount of investigational work has been carried out in this country with a view to ascertaining the extent to which the productiveness of the soil is affected by the variety of crop grown, by varying conditions of soil and moisture, by crop pests and diseases, etc., but the literature on these different factors in crop-production is not available in a handy form. It is buried away in farm reports, bulletins, memoirs, etc., in the archives of Agricultural Departments and tends to get lost sight of. The book under review gives a résumé of the more important results obtained by investigators in this field of research. It describes, too, in some detail the organization adopted in the different provinces for the propagation and distribution of the improved varieties of seed evolved. It goes further in indicating the vast fields for research which still remain untouched, and in suggesting ways and means of attacking problems awaiting solution.

The author treats the subject of crop-production under three heads, *viz.*, the soil, the crop and the organization required for bringing the results of the investigator within the realm of farm practice. Within the last century or so the subject of soil fertility in its relation to plant nutrition has been closely studied by scientists such as Liebig, Hellriegel, Lawes, Gilbert, Cameron, Hall and Russell ; in the book under review, however, the subject is discussed from a somewhat broader point of view. The plant has been regarded as the centre of the subject ; the various soil and other factors have been considered in their relation to the welfare of the plant.

Surface drainage and irrigation are two of the factors which play an important part in crop-production in this country. We cannot control either the amount or the irregular distribution of the monsoon ; but a great deal can be done in regulating it for the benefit of crops after it has fallen, and to check soil erosion. Drainage is closely bound up with the question of soil aeration and fertility in which even the rivers and streams play a significant part. They both help to ventilate the soil ; for like sub-soil drains they draw water out of the earth, and the fall in the level of the sub-soil water is accompanied by an in-draught of air into the soil from the atmosphere. The aeration of soil thus brought about encourages bacterial action and nitrification, and thereby makes for soil improvement and larger outturns.

Irrigation, too, admittedly adds considerably in this country to the yield of the crop irrigated ; but where the water is supplied from Government canals an excessive

amount is used at times to the detriment of the crop. The author therefore strongly recommends that the present method of assessment, according to the area watered and according to the crop grown, should gradually give place to the sale of water by volume as suggested by the last Irrigation Commission. A great incentive to water saving would then, he avers, be automatically provided.

After the regulation of the water-supply, the solution of the nitrogen problem is the next step in the development of Indian agriculture. While experience shows that crop-production can be materially developed by improving the water-supply, nevertheless the highest duty of water is only reached when we increase at the same time the supply of combined nitrogen. Both these must be adequate if the optimum results are desired. After arranging for water, the problem is gradually to increase the nitrogen supply by methods within the means of the cultivator. This can be done either by reducing the losses of nitrogen or by increasing the amount added to the soil. Two views are held in India as to the best way of increasing the nitrogen supply. One side holds that all that is necessary is to check the vital losses, to stimulate nitrogen fixation, to improve the process of green manuring, to get the most out of oil-cakes, and to introduce methods of composting organic manures similar to those in use in China and Japan. The other view is that such methods will not suffice, and that artificial manures are necessary. Before, however, any reliable decision can be arrived at as to the best method of solving the nitrogen problem, a good deal of careful experiment will be necessary. Agricultural Departments have as yet but touched the fringe of this big problem.

But perhaps the most important chapters in the book are those dealing with the improvement of varieties of crops and the various systems adopted in the provinces and at Pusa for propagating and distributing the improved seed evolved. Three lines of advance are possible in improving the variety so that more produce and a more even product can be obtained. These are acclimatization, selection and hybridization. Of these, the last two have proved the more successful in India. But whatever method of improving the crop is adopted, certain varietal characters will always be of paramount importance. The first of these is yielding power. It is quite useless to bring any new variety to the notice of the people unless it yields well under their conditions. Every cultivator understands the meaning of a good crop and of a variety which can be relied upon to produce an yield above the average. Once this is assured, the success of any new introduction is certain, and no difficulty in obtaining his co-operation need be feared. Payment for yield is easy and immediate ; but payment for improved quality is often a slow process.

In the chapter on " disease in plants " the two methods of dealing with diseases of crops are discussed, namely, (1) direct methods, which include the destruction of the parasite and the prevention of infection, and (2) the indirect methods, such as the avoidance of disease altogether by the selection of disease-resistant varieties and by the increase of the natural resistance of the plants. The author is a strong believer in indirect methods ; prevention, he thinks, is better than cure. He believes

that the introduction of suitable resistant varieties and proper methods of cultivation are the most important factors in the control and elimination of crop pests and diseases. Resistance to disease can, he thinks, be increased by improving the texture of the soil ; red-rot in cane, for example, appears to be the natural result of poor soil aeration resulting from water-logging. Varieties differ greatly among themselves in resistance to diseases and to the ravages of insect pests, and the incidence of these diseases and pests can therefore be greatly reduced by selection.

The book should find many readers among the landed aristocracy of India ; it should prove useful and interesting also to Government officials connected with the Agricultural and Irrigation Departments, as well as to all district officials who have the advancement of agriculture India's greatest industry—at heart. It is written in an admirably clear style, in which the words are fitly chosen to express the meaning. The author refers very generously to the contributions to the betterment of agricultural methods made by his colleagues in the department. Many of these pioneers of agricultural science in this country have, like the author himself, devoted the best part of their lives to the service and cause of science and carried on in the face of hardships and adverse conditions. [D. C.]

Wealth and Taxable Capacity of India.—By K. T. SHAH and K. J. KHAMBHATA. (D. B. Taraporevala Sons & Co., and P. S. King & Son, Ltd., Bombay and London.)

IT is not possible to present a complete discussion of the contents of this important book, because the argument is derived all through from the examination of estimates of production all of which require very careful scrutiny, for instance, their tenet that India derives no dividend from its 143 million cattle. The authors' object is to estimate the annual income or dividend of India, in the sense of the value of the production of tangible commodities. The gross value which Mr. Khambhata arrives at divided by the number of the population gives a *per capita* average annual figure of Rs. 74. He then deduces that in view of the unequal distribution of incomes the average income of " the poor " (the term is not defined) " may not be less than Rs. 60 per head per annum. This means Rs. 5 per month. Is this the wealth of India or its poverty ? What can a poor ryot do with possibly less than Rs. 5 per month but starve himself gradually to death " This, which seems to be the kernel of the whole book, is a pretty stiff statement. Many millions of Indians seem to survive successfully this unpleasant process of slow starvation. And the steady absorption of gold and silver by India is not a phenomenon which can easily be associated with such utter poverty—almost universal existence below the minimum subsistence level— as is suggested by the authors of this book.

But the really serious thing is that there is in the passage quoted a confusion of economic thought. The authors have deliberately excluded " services " from their

estimate of " national dividend ", and we have no dispute with them on that account. Their method of arriving at a total production value of tangible goods may be perfectly sound. But such a value is not convertible into terms of private incomes, since services there enter in. If money circulates from one hand to another during the year it counts twice in the estimate of private incomes. For instance, a rich man pays from income Rs. 1,000 to a doctor for an operation. This sum is annual private income both to the rich man and to the doctor. The doctor pays Rs. 360 to a private servant in return for the satisfaction received for his services. Here again Rs. 360 must be counted to the incomes of both the doctor and the servant.

We believe that the best way of arriving at the values of annual private incomes, and the distribution of incomes (" distribution " is here used in the statistical and not in the economic sense) is by the collection of family budgets on a scale not so far attempted in this country. But that is another matter. For the moment we only say that it seems a pity that the authors of this valuable book have allowed this confusion of economic thought to obscure the minds of their readers. The man in the street does not consider what portion of the " national dividend " is by arithmetic average assignable (as a purely theoretical conception) to himself, but how much he has to spend. And these two measures are in no way identical or even homologous. [Extracts from *The Labour Gazette*, Bombay, Vol. IV, No. 4.]

NEW BOOKS

On Agriculture and Allied Subjects

1. Elements of Land Economics, by Dr. Richard T. Ely and Edward W. Morehouse. Pp. xviii+363. (New York: The Macmillan Co.) Price, 17*s*. net.
2. Introduction to Agricultural Economics, by Dr. Lewis Cecil Gray. (Social Science Text-books.) Pp. xii+556. (New York: The Macmillan Co.) Price, 12*s*. net.
3. Elements of Rural Economics, by Prof. Thomas Nixon Carver. Pp. v+266. (Boston and London: Ginn & Co.) Price, 7*s*. net.
4. A Short System of Farm Costing, by H. R. J. Holmes. Pp. 107. (London: Oxford University Press.) Price; 6*s*. 6*d*. net.
5. Farm Accounting, by Prof. E. L. Currier, Prof. N. J. Lennes and Prof. A. S. Merrill. Pp. ix+287. (New York: The Macmillan Co.) Price, 7*s*. net.
6. Cane Sugar and its Manufacture, by H. C. Prinsen Geerligs. Second revised edition. Pp. ix+342. (London: Norman Rodger.) Price, 20*s*. net.
7. The Principles of Dairying, Testing and Manufactures. Pp. xvii+279. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd.) Price, 10*s*. net.

The following publications have been issued by the Imperial Department of Agriculture since our last issue:—

Memoir

1. The Eradication of *Cyperus rotundus* L.: A study in Pure and Applied Botany, by S. B. Ranade, B.Sc., and arranged and written by W. Burns, D.Sc. (Botanical Series, Vol. XIII, No. 5.) Price, Rs. 2 or 3*s*.

Reports

3. Review of Agricultural Operations in India, 1923-24. Price, Rs. 1-9-0 or 2*s*. 9*d*.
4. Report of the Imperial Bacteriological Laboratory, Muktesar, for the two years ending 31st March, 1924. Price Rs. 1-8 or 2*s*. 6*d*.

List of Agricultural Publications in India from the 1st August 1924 to the 31st January 1925

No.	Title	Author	Where Published
	GENERAL AGRICULTURE		
1	The Agricultural Journal of India, Vol. XIX, Parts V and VI, and Vol. XX, Part I. Price, Re. 1-8 or 2*s.* per part. Annual subscription Rs. 6 or 9*s.* 6*d.*	Edited by the Agricultural Adviser to the Government of India.	Vol. XIX, Parts V & VI by Messrs. Thacker, Spink & Co., Calcutta, Vol. XX, Part I by the Manager, Government of India, Central Publication Branch, Calcutta.
2	Scientific Reports of the Agricultural Research Institute, Pusa (including the Reports of the Imperial Dairy Expert, the Physiological Chemist and the Secretary, Sugar Bureau, for 1923-24. Price, Re. 1 or 1*s.* 8*d*	Issued from the Agricultural Research Institute, Pusa.	Government of India, Central Publication Branch, Calcutta.
3	Review of Agricultural Operations in India, 1923-24. Price, Re. 1-9 or 2*s.* 9*d.*	Agricultural Adviser to the Government of India.	Ditto
4	Birds of an Indian Garden. Price Rs 12.	T. Bainbrigge Fletcher, R. N., F.L.S., F.E.S., F.Z.S., Imperial Entomologist, Pusa, and C M Inglis, M.B O.U , F E.S., F Z S.	Messrs. Thacker, Spink & Co , Calcutta
5	Estimates of Area and Yield of Principal Crops in India, 1923-24. Price, As. 9 or 1*s.*	Issued by the Department of Commercial Intelligence and Statistics, India.	Government of India, Central Publication Branch, Calcutta.
6	Agricultural Statistics of India, 1921-22, Vol. II. Price, As. 15.	Ditto	Ditto
7	Report on the Operations of the Department of Agriculture, Madras Presidency, for the official year 1923-24.	Issued by the Department of Agriculture, Madras.	Government Press, Madras.
8	Sugar Industry in Western India and Methods of Sugar Manufacture. Bombay Department of Agriculture Bulletin No. 116. Price, Re. 1-2	R. G. Padhye B.Ag. (Bom.), M. S. (La,U. S. A.), Sugar Chemist and Technologist.	Yeravda Prison Press.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where Published
	General Agriculture—contd.		
9	Investigations in Fig Culture and Treatment. Bombay Department of Agriculture Bulletin No. 117. Price, As. 5 6.	S. R. Gandhi, B. Ag., Demonstrator in Horticulture, Poona Agricultural College.	Yeravda Prison Press.
10	Year Book of the Agricultural Department in the Southern Division, 1924. Bombay Department of Agriculture Bulletin No. 119. Price, As. 4-6.	Issued by the Department of Agriculture, Bombay.	Ditto
11	Annual Report of the Department of Agriculture in the Bombay Presidency for the year 1923-24.	Ditto	Ditto
12	History of Experiments with improved Jute in Bengal Districts.	D. N. Mitra, District Agricultural Officer, Faridpur.	Bengal Government Press, Calcutta.
13	Recommendation regarding Crops and Manures and Cattle. Bengal Department of Agriculture Bulletin No. 1 of 1925.	Issued by the Department of Agriculture, Bengal.	Ditto
14	Recommendation regarding Crops and Manures and Cattle. Bengal Department of Agriculture Bulletin No. 2 of 1925.	Ditto	Ditto
15	Seasonal Notes for October 1924. Price, As. 3.	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
16	Annual Report on the Operations of the Department of Agriculture, Punjab, Part II, for the year ending 30th June 1923. Price, Volume I Rs. 3-12 and Vol. II Rs. 7-8.	Ditto	Ditto
17	Field Rats and their Control. Punjab Department of Agriculture Leaflet No. 30.	Ditto	Ditto
18	Punjab Department of Agriculture Leaflet No. 16 (Revised 1924) on Castor (*ricinus communis*).	Ditto	Ditto
19	Season and Crop Report, Punjab, for 1923-24.	Ditto	Ditto
20	Tables of Agricultural Statistics for 1923-24 of the Punjab Department of Agriculture.	Ditto	Ditto

List of Agricultural Publications—*contd.*

No.	Title	Author	Where Published
	General Agriculture—contd.		
21	Annual Report on the Administration of the Department of Agriculture, United Provinces, for the year ending 30th June, 1924.	Issued by the Department of Agriculture, United Provinces, Allahabad.	Government Press, United Provinces, Allahabad.
22	Annual Report on the Agricultural Stations in the Central Circle, United Provinces, for the year 1923-24.	Ditto	Ditto
23	Report on the Agricultural Stations of the Western Circle, United Provinces, for the year ending 31st May, 1924.	Ditto	Ditto
24	Report on the Agricultural Stations in the Eastern Circle, United Provinces, for the year ending 31st May, 1924.	Ditto	Ditto
25	Report on the Agricultural Stations in the North-eastern Circle, United Provinces, for the year 1923-24.	Ditto	Ditto
26	Report on the Agricultural Stations in the Rohilkhand Circle, United Provinces, for the year ending 31st May 1924.	Ditto	Ditto
27	Report on the Working and Administration of United Provinces Government Gardens for the year 1923-24.	Ditto	Ditto
28	Agricultural Statistics for Bihar and Orissa for 1923-24.	Issued by the Department of Agriculture, Bihar and Orissa.	Government Press, Gulzarbagh
29	Agricultural Statistics of Burma for the year 1923-24. Price, Re. 1-8	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon
30	Report on the Operations of the Department of Agriculture, Burma, for the year ended 30th June, 1924.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
31	Report of the Mandalay Agricultural Station for the year ended 30th June, 1924.	Ditto	Ditto

List of Agricultural Publications—*contd.*

No.	Title	Author	Where Published.
	General Agriculture—contd.		
32	Report of the Hmawbi Agricultural Station for the year ended 30th June, 1924.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
33	Report of the Mahlaing Agricultural Station for the year ended 30th June, 1924.	Ditto	Ditto
34	Report of the Tatkon Agricultural Station for the year ended 30th June, 1924.	Ditto	Ditto
35	Report of the Akyab Agricultural Station for the year ended 30th June, 1924.	Ditto	Ditto
36	Report of the Hopin Agricultural Station for the year ended 30th June, 1924.	Ditto	Ditto
37	Report of the Padu Agricultural Station for the year ended 30th June, 1924.	Ditto	Ditto
38	Report of the Yawnghwe Agricultural Station for the year ended 30th June, 1924.	Ditto	Ditto
39	Report of the Allanmyo Agricultural Station and Pwinbyu Seed Farm and Annual Reports of the Agricultural Chemist, Superintendent Stock Breeding, Economic Botanist, Mycologist, Entomologist and Sericultural work, Burma, for the year ended 30th June, 1924	Ditto	Ditto
40	Wheat Cultivation. Burma Department of Agriculture Cultivators' Leaflet No. 1.	Ditto	Ditto
41	The Storage of Cattle Manures. Burma Department of Agriculture Cultivators' Leaflet No. 3.	Ditto	Ditto
42	The Cultivation of Groundnut. Burma Department of Agriculture Cultivators' Leaflet No. 4	Ditto	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where Published
	General Agriculture—contd.		
43	Cultivation of Cabbage, Cauliflower, Knol-khol and Lettuce. Burma Department of Agriculture Cultivators' Leaflet No. 6.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
44	Cultivation of Carrot, Raddish and Beet. Burma Department of Agriculture Cultivators' Leaflet No. 7.	Ditto	Ditto
45	Bean Cultivation. Burma Department of Agriculture Cultivators' Leaflet No. 8.	Ditto	Ditto
46	Tobacco Cultivation. Burma Department of Agriculture Cultivators' Leaflet No. 9.	Ditto	Ditto
47	Leguminous Crops cultivated for their Roots. Burma Department of Agriculture Cultivators' Leaflet No. 10.	Ditto	Ditto
48	Cultivation of Cotton. Burma Department of Agriculture Cultivator's Leaflet No. 11.	Ditto	Ditto
49	Cultivation of Jute. Burma Department of Agriculture Cultivators' Leaflet No. 12.	Ditto	Ditto
50	The Use of the Small Bullock Hoe (Tun-do). Burma Department of Agriculture Cultivators' Leaflet No. 13.	Ditto	Ditto
51	Coconut Cultivation in Arakan. Burma Department of Agriculture Cultivators' Leaflet No. 15.	Ditto	Ditto
52	Sunn-hemp Cultivation. Burma Department of Agriculture Cultivators' Leaflet No. 17	Ditto	Ditto
53	The Seed Drill. Burma Department of Agriculture Cultivators' Leaflet No. 18.	Ditto	Ditto
54	Two Useful Rice-pounders used in the Shan States. Burma cultivators' Leaflet No. 22.	Ditto	Ditto

List of Agricultural Publications—*contd.*

No.	Title	Author	Where published
	General Agriculture—contd.		
55	Cultivation of Castor Oil. Burma Department of Agriculture Cultivators' Leaflet No. 23.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
56	Pebyugale. Burma Department of Agriculture Cultivators' Leaflet No. 30.	Ditto	Ditto
57	Dry weather cultivation of Burmese Vegetables on paddy soils. Burma Department of Agriculture Cultivators' Leaflet No. 31.	Ditto	Ditto
58	Note on Formation of Bamboo Plantations. Burma Department of Agriculture Cultivators' Leaflet No. 34.	Ditto	Ditto
59	Sugarcane Cultivation. Burma Department of Agriculture Cultivators' Leaflet No. 35.	Ditto	Ditto
60	Guinea grass (*Panicum maximum*). Burma Department of Agriculture Cultivators' Leaflet No. 44.	Ditto	Ditto
61	Cambodia Cotton. Burma Department of Agriculture Cultivators' Leaflet No. 45.	Ditto	Ditto
62	The Cultivation of Onions. Burma Department of Agriculture Cultivators' Leaflet No. 46.	Ditto	Ditto
63	The Cultivation of Pe-Sin-ngoon or Pigeon Pea (*Cajanus indicus*). Burma Department of Agriculture Cultivators' Leaflet No. 47.	Ditto	Ditto
64	Instructions for the Culture and Manufacture of Tea. Burma Department of Agriculture Cultivators' Leaflet No. 49.	Ditto	Ditto
65	Instructions for the Culture and Manufacture of Coffee. Burma Department of Agriculture Cultivators' Leaflet No. 50.	Ditto	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture —contd.		
66	The Manufacture of Jaggery. Burma Department of Agriculture Cultivators' Leaflet No. 51.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
67	The new and improved type of Jaggery Furnace. Burma Department of Agriculture Cultivators' Leaflet No. 52.	Ditto	Ditto
68	Report of the Agricultural Department, Assam, for the year ending 31st March 1924.	Issued by the Department of Agriculture, Assam.	Assam Secretariat Printing Office, Shillong.
69	Assam Department of Agriculture Leaflet on "Our Buffaloes and Cows and means of their Improvement" (in Assamese).	Ditto	Ditto
70	The *Bengal Agricultural Journal* (Quarterly), (in English and Bengali). Annual subscription, Re. 1-4. Single copy, As 5.	Issued by the Department of Agriculture, Bengal.	Sreenath Press, Dacca.
71	The *Journal of the Madras Agricultural Students' Union* (Monthly) Annual subscription, Rs. 4.	Madras Agricultural Students' Union.	The Electric Printing Works, Coimbatore.
72	*Quarterly Journal of the Indian Tea Association.* Price, As. 6 per copy.	Scientific Department of the Indian Tea Association, Calcutta.	Catholic Orphan Press, Calcutta.
73	*Poona Agricultural College Magazine* (Quarterly). Annual subscription, Rs. 2.	College Magazine Committee, Poona.	Arya Bhusan Press, Poona.
74	*Journal of the Mysore Agricultural and Experimental Union.* (Quarterly.) Annual subscription, Rs. 3.	Mysore Agricultural Experimental Union.	Bangalore Press, Bangalore.
75	*Indian Scientific Agriculturist.* (Monthly.) Annual subscription, Rs. 4.	H. C. Sturgess, Editor; J. W. McKay, A.R.C.Sc., N.D.A., Consulting Editor.	Calcutta Chromotype Co., 52-53, Bow Bazar Street, Calcutta.
76	The *Planters' Chronicle* (Weekly)	United Planters' Association of South India, Coimbatore.	E. P. Works, Coimbatore.
77	*Rural Bengal* (Monthly) . .	N. N. Gupta, B.A., Ph.D., B.Sc., Editor.	Russa Art Press, Bhowanipur, Calcutta.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	General Agriculture—concld.		
78	*Krishak* (Bengali) (Monthly). Price, As. 5 per copy. Annual subscription, Rs. 3-3.	U. C. Bannerji, Editor	Sri Ram Press, 162, Bow Bazar Street, Calcutta.
79	The *Old Boy's Magazine, Agricultural College, Cawnpur* (Quarterly). Price, As. 8 per copy. Annual subscription, Rs. 2.	M. L. Saksena, L.Ag., Editor.	Cawnpore Printing Press.
	AGRICULTURAL CHEMISTRY		
80	The Buffer action of some Burma Soils. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. VII, No. 5. Price, As. 12 or 1*s*.	J. Charlton, M.Sc., A.I.C., Agricultural Chemist, Burma.	Messrs. Thacker, Spink & Co., Calcutta.
81	Studies in the Chemistry of Sugarcane, II. Some Factors that determine the ripeness of Sugarcane. Memoirs of the Department of Agriculture in India, Chemical Series, Vol VII, No. 6. Price, As. 8 or 9*d*.	B. Viswanath, F.I.C., Offg Government Agricultural Chemist, and S. Kasinath Ayyar, B.A., Assistant to the Government Agricultural Chemist, Coimbatore.	Ditto
	BOTANY		
82	The Eradication of *Cyperus rotundus* L. A study in Pure and Applied Botany. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XIII, No. 5. Price, Rs. 2-4 or 3*s*.	S. B. Ranade, B.A., M.Sc., and arranged and written by W. Burns, D.Sc. (Edin.) Economic Botanist, Bombay.	Messrs. Thacker, Spink & Co., Calcutta.
	MYCOLOGY		
83	The Mahali Disease of Coconuts in Malabar. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XIII, No. 4. Price, As. 12 or 1*s*.	S. Sundararaman, M.A., Offg. Government Mycologist, Coimbatore, and T. S. Ramakrishnan, M.A., Assistant in Mycology, Coimbatore.	Messrs. Thacker, Spink & Co., Calcutta.
84	Studies in Diseases of the Jute Plant, (2) *Macrophoma Corchori* Saw. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XIII, No. 6. Price, As. 8 or 9*d*.	F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S., Offg. Imperial Economic Botanist, Pusa.	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	Mycology—concld.		
85	Red Rot Disease of Sugarcane. Burma Department of Agriculture Cultivators' Leaflet No. 5.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
86	The symptoms of "Ufra" Disease of Rice. Burma Department of Agriculture Cultivators' Leaflet No. 33.	Ditto	Ditto
87	Jowar Smut. Burma Department of Agriculture Cultivators' Leaflet No. 37.	Ditto	Ditto
	ENTOMOLOGY		
88	List of Publications on Indian Entomology, 1923. Pusa Agricultural Research Institute Bulletin No. 155. Price, As. 11 or 1s.	Compiled by the Imperial Entomologist, Pusa.	Government of India, Central Publication Branch, Calcutta.
89	Catalogue of Indian Insects, Part 5 *Nitidulidæ*. Price, As. 10.	S. N. Chatterji, F.E.S., Lower Grade Assistant, Entomological Branch. Forest Research Institute, Dehra-Dun.	Ditto
90	The Army Worm of Paddy Madras Department of Agriculture Leaflet No. 38 (English, Tamil, Telegu, Kanarese and Malayalam).	Rao Sahib Y. Ramachandra Rao, M.A., Government Entomologist, Coimbatore.	Government Press, Madras.
91	Tobacco Aphis. Madras Department of Agriculture Leaflet No. 39.	Ditto	Ditto
92	Land Crabs as Agricultural Pests in Western India. Bombay Department of Agriculture Bulletin No. 118. Price, As. 8.	P. V. Wagle, B.Ag., Inspector of Agriculture on special duty, Tatta.	Yeravda Prison Press.
93	Instructions on Silkworm rearing. Burma Department of Agriculture Bulletin No. 21.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon
94	Po-di-goung and Po-kyaing-gaung (Chafer Beetles and their grubs). Burma Department of Agriculture Cultivators' Leaflet No. 2.	Ditto	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published
	Entomology—contd.		
95	The important Insect Pests of the Coconut in Burma and how to check them. Burma Department of Agriculture Cultivators' Leaflet No. 14.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
96	The Red Cotton Bug (Wa Gon Po Ni). Burma Department of Agriculture Cultivators' Leaflet No. 16.	Ditto	Ditto
97	The Rice Hispa (Phalan-po or Po-laung-mi). Burma Department of Agriculture Cultivators' Leaflet No. 19.	Ditto	Ditto
98	Nga-Hmyaung-Doung (*Spodoptera mauritia*). Burma Department of Agriculture Cultivators' Leaflet No. 20.	Ditto	Ditto
99	The Lemon Butterfly. Burma Department of Agriculture Cultivators' Leaflet No. 21.	Ditto	Ditto
100	Crabs in Paddy Fields. Burma Department of Agriculture Cultivators' Leaflet No. 24.	Ditto	Ditto
101	The Common Hairy Caterpillars (Khu-gaung). Burma Department of Agriculture Cultivators' Leaflet No. 24.	Ditto	Ditto
102	Fruit Flies. Burma Department of Agriculture Cultivators' Leaflet No. 26.	Ditto	Ditto
103	The Cotton Bollworms. Burma Department of Agriculture Cultivators' Leaflet No. 27.	Ditto	Ditto
104	The Brown *Cerocceus Libisci* Green (Wa-K a i n g-s a n t-P o-W a). Burma Department of Agriculture Cultivators' Leaflet No. 28.	Ditto	Ditto
105	Field Crickets (Payit). Burma Department of Agriculture Cultivators' Leaflet No. 29.	Ditto	Ditto
106	Rats damaging Paddy. Burma Department of Agriculture Cultivators' Leaflet No. 36.	Ditto	Ditto

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title	Author	Where published.
	Entomology—concld.		
107	The Rice Case-worm (Ywet-hyat-po). Burma Department of Agriculture Cultivators' Leaflet No. 38.	Issued by the Department of Agriculture, Burma.	Government Printing' Burma, Rangoon
108	The Army Worm (*Cirphis unipuncta*). Burma Department of Agriculture Cultivators' Leaflet No. 39.	Ditto	Ditto
109	The Paddy Grain Moth (*Sitotroga cerealella*). Burma Department of Agriculture Cultivators' Leaflet No. 40.	Ditto	Ditto
110	The Paddy ear-cutting Caterpillar (*Cirphis unipuncta*). Burma Department of Agriculture Cultivators' Leaflet No. 41.	Ditto	Ditto
111	The Paddy Stem Borers (Sit-po). Burma Department of Agriculture Cultivators' Leaflet No. 42.	Ditto	Ditto
112	Seed Storage and Prevention of Damage by Insects. Burma Department of Agriculture Cultivators' Leaflet No. 48.	Ditto	Ditto
	VETERINARY		
113	Annual Administration Report of the Civil Veterinary Department, Madras Presidency, for the year 1923-24.	Issued by the Civil Veterinary Department, Madras.	Government Press, Madras.
114	Annual Administrative Reports of the Bombay Veterinary College, Glanders and Farcy Department, and Civil Veterinary Department in the Bombay Presidency (including Sind) for the year 1923-24. Price, As. 5-6.	Issued by the Civil Veterinary Department Bombay.	Government Central Press, Bombay
115	Annual Report of the Bengal Veterinary College and Civil Veterinary Department, Bengal, 1923-24, Price, Re. 1.	Issued by the Civil Veterinary Department, Bengal.	Bengal Government Press, Calcutta.
116	A note on treatment of Surra in Ponies by Tartar Emetic. Punjab Veterinary Bulletin No. 13 (reprinted in 1925).	Kahan Singh, G.P.V.C., P.V.S., Officer in charge of Camel Specialist's Office, Sohawa.	Government Printing, Punjab, Lahore.

List of Agricultural Publications—*contd.*

No.	Title	Author	Where published
	Veterinary—contd.		
117	List of dates of Horse and Cattle Fair Shows to be held in the Punjab during 1924-25.	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
118	A note on treatment of Surra in Donkeys by intravenous injections of Tartar Emetic.	Kahan Singh, G.P.V.C., P.V.S., Officer in charge of Camel Specialist's Office, Sohawa.	Ditto
119	Annual Report of the Camel Specialist for the year 1923-24. Price, As. 4.	Issued by the Department of Agriculture, Punjab.	Ditto
120	Annual Report of the Civil Veterinary Department, Bihar and Orissa, for the year 1923-24. Price, As. 12.	Issued by the Civil Veterinary Department, Bihar and Orissa.	Government Printing, Bihar and Orissa, Patna.
121	Annual Report of the Civil Veterinary Department, United Provinces, for the year ending 31st March 1924. Price, Re. 1-4-0.	Issued by the Civil Veterinary Department, United Provinces.	Government Press, United Provinces, Allahabad.
122	Report of the Civil Veterinary Department of the Central Provinces and Berar for the year 1923-24. Price, Re. 1.	Issued by the Civil Veterinary Department, Central Provinces and Berar.	Government Press, Central Provinces, Nagpur.
123	Report of the Civil Veterinary Department (including the Insein Veterinary School), Burma, for the year ending 31st March 1924. Price, Re. 1.	Issued by the Civil Veterinary Department, Burma.	Government Printing, Burma, Rangoon.
124	Anti-Rinderpest Serum. Burma Department of Agriculture Cultivators' Leaflet No. 32.	Issued by the Department of Agriculture, Burma.	Ditto
125	The Branding, Flaying and Curing of Hides. Burma Department of Agriculture Cultivators' Leaflet No. 43.	Ditto	Ditto
126	Report of the Civil Veterinary Department, Assam, for the year 1923-24. Price, As. 8 or 9*d*.	Issued by the Civil Veterinary Department, Assam.	Assam Secretariat Printing Office, Shillong.
127	Report of the Civil Veterinary Department, North-West Frontier Province, for the year 1923-24. Price, As. 12.	Issued by the Civil Veterinary Department, North-West Frontier Province.	North-West Frontier Province Government Press.

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EDITORIAL

WRITING about two centuries ago on the subject of the importance of agriculture to the State, Young said, " Agriculture is, beyond all doubt, the foundation of every other art, business and profession, and it has, therefore, been the ideal policy of every wise and prudent people to encourage it to the utmost." Let us consider how far this sentiment is appreciated in India in which agriculture is our premier industry, providing as it does 3 out of every 4 of the people with a means of livelihood. The first business of statesmanship, we are told, is to recognize established facts and to act upon their evidence. How far have our statesmen and the people themselves recognized facts and taken action on the evidence available regarding the needs of agriculture in this country ? The facts are that agriculture in India has attracted little in the way of brains, enterprise or capital in the past. Most of the rule of thumb methods of the cultivator are based on medieval systems which are inefficient and primitive like his *deshi* plough which has been in use for thousands of years. Empirical methods have gone as far as they can, little more can be done without the help of the scientific worker. None the less progress is now taking place and scientific development is going on, for within the last 20 years Government has built up a small but efficient Department of Agriculture—the experts of which have by research and experiment laid the foundations on which the edifice of scientific agriculture with its new and improved practices is being slowly erected. In almost every branch of husbandry, elaborate investigations have been carried out, for knowledge had to be acquired and a basis of facts established before any progress in evolving improvements could be effected. Agricultural colleges and research institutes have been established and young Indians trained in large numbers in the theory and practice of scientific agriculture. Thousands of varieties of crops have been sorted out from the heterogeneous mixtures grown by the cultivator. The varying varieties and strains have been tested in the field, and the more desirable types from the point of view of productiveness, quality, disease-resistance and other factors determining their value have been propagated on Government farms and on private seed farms for distribution in the villages. The area now sown in India with seed of new forms improved by selection and crossing exceeds 5 million acres and is increasing every year.

In the improvement of cattle the same principle is being followed ; improved types are being established by selection and cross-breeding. Within the last 15 years the milk yield of the Montgomery herd on the Pusa farm has been doubled by selective breeding, while by cross-breeding a type of Ayrshire-Montgomery has been evolved which gives 50 per cent. more milk in a lactation period than the best

of the selected Montgomery cows on that farm. Some of these cross-breds have given 12,000 lb. of milk in a lactation period, while the majority of the Montgomery cows have given over 4,000 : the average yield of an Indian cow does not, it may be mentioned, exceed 800 lb. The breeds now being established in India will, we believe, form the basic stock for the development of a future cattle-breeding and dairy industry ; and cultivators will a century or so hence trace the origin of their well-bred kine and improved seed to the pedigree stock and new strains of seed now being evolved on Government farms in this country. They will in the same way trace the origin of their improved implements and methods of tillage, the protection of their cattle against disease, the prevention of crop diseases and the economical use of water and manures to the researches which are at the present time being carried out in the different provinces in India. The money value of these improvements to the country is enormous. The increased profits now being derived from the introduction of improved seed alone, cover the cost of the Imperial and Provincial Departments of Agriculture in India five times over, and seed improvement is but one of the many achievements of these departments.

Viceroys come and go ; their beneficent work remains behind them to keep their names alive. To that Great Viceroy the late Lord Curzon India is indebted for the new era of scientific research which he inaugurated and for the valuable economic results which it is producing. He realized that agriculture was India's fundamental industry, and that the State should foster agricultural research. The policy which he initiated has been given effect to, and within the last two decades much has already been achieved and a vista of further progress opened out.

Let us next consider how far the people themselves have recognized facts and taken action on the evidence available regarding the needs of agriculture in this country. In our Legislative Councils industrial development is sometimes urged ; but the people who press for it almost always think in terms of industries other than agriculture. That agriculture is, and always will be, India's greatest industry, and that the Department of Agriculture has already done much to advance that industry and at a very small cost are facts which they have not yet thoroughly grasped. This, however, is we believe but a passing phase, due largely to lack of enlightenment as to the needs of rural India. It is a phase to which the non-co-operation movement gave much encouragement while it lasted. It is a phase which will tend to disappear when the finances of the State improve, when more money becomes available for the nation-building departments, and when the hundreds of young Indians trained in our agricultural colleges, and the tens of thousands of landholders who are already co-operating most heartily with the department rise to the occasion, and use their influence in selecting for their Legislative Councils representatives who understand their economic needs and take a broad and enlightened view of agricultural development. These tens of thousands are still largely inarticulate ; and they have not as yet been able to visualize and state their requirements with force and precision.

Of all the lines of work now receiving the attention of our agricultural experts, none perhaps is of more importance than that of cattle-breeding and dairying, and the protection of cattle against diseases. These different aspects of husbandry will, in future numbers of this Journal, receive special attention. In the present number will be found the first of a series of articles from the Muktesar Institute on "Some recent advances in the protection of cattle and other animals against disease."

ORIGINAL ARTICLES

SOME RECENT ADVANCES IN THE PROTECTION OF CATTLE AND OTHER ANIMALS AGAINST DISEASE.

[PAPERS FROM THE IMPERIAL INSTITUTE OF VETERINARY RESEARCH, MUKTESAR. (*Director*, MR. J. T. EDWARDS; *Secretary for Publications*, MR. S. K. SEN.).]

I

A request was received from the President of the Agricultural Section of the Indian Science Congress to be held at Bangalore in February 1924 to prepare a summary of the information available upon the above subject. Two short papers were submitted, which have not hitherto been published. Again, for the meeting of the Congress held at Benares in February of this year a lengthy series of papers was prepared, and it is now intended to publish the information contained in these papers in a suitably extended form in this *Journal* for the special benefit of the stock-owner in India.

Before proceeding with the discussion of the several diseases which commonly affect livestock in India and the means at our disposal in the light of present knowledge to combat them by prevention or cure, it has been thought that it would not be without interest to the reader to have explained to him some first principles in regard to disease, or, what is almost tantamount in significance, the maintenance in health, of animals.

To the ordinary man the definition of the word disease is something which does not present great difficulty, but to the critically trained mind, it is a term which, like so many other terms of simple interpretation at merely casual examination, in reality, is one not understood without considerable difficulty. When a layman thinks of disease, what occurs to him is a series of mental pictures or associations connected mainly with his ordinary visual experiences. He will perhaps think of a friend whom he has generally regarded as a man of vigour accustomed to the performance of certain tasks but who is stricken with disability to perform what he has been accustomed to accomplish. Moreover, this friend may suffer what he terms pain and express anxiety. In any case, the picture of this friend suffering from disease is something different from the picture of what he regards as that of the opposite condition, namely, health, in which he had placed this man in his previous mental associations. The two pictures to the mind are so different that a

definition is very obvious and, even more, that one may postulate or consider axiomatic the terms disease and health. To the mind of a person trained in these matters, however, there will occur at once certain ideas which will make him hesitate to submit a definition of either of these terms. The possessor of such a mind will probably be affected by the knowledge that the man who was suffering in the above cited example had been affected perhaps with attacks of malaria, in the nature of repeated relapses, and that during his periods of apparent health he was harbouring in his system the parasites of the disease, which subsequently for some reason from time to time gained the ascendancy over the powers of resistance possessed by the man's system and hence produced the picture of disease. He would thus consider that the man was not in reality perfectly healthy, even during the periods when he appeared to be in good health, for he was harbouring in his system the parasites of a serious disease.

One may carry this critical attitude further and take into consideration a disease like human pneumonia, following upon a more or less severe attack of influenza. Now, it is extremely probable that the causal agents of the pneumonia, namely, one or more types of minute organisms known as pneumococci, were already residing in the upper air passages of the subject in a state of subdued activity prior to the onset of the attack of influenza. The initial attack of disease, that is, of influenza, had depressed the powers of resistance of the individual to such an extent that the pneumococci were able to propagate and cause secondarily serious changes in the lung tissue? The question now arises as to whether an individual harbouring germs possessed of such potential danger can be considered free from disease.

We may take another example of the kind which produces hesitancy in the critical mind. The man who was to the lay mind perfectly healthy in appearance might be found at *postmortem* examination to harbour in reality lesions, that is, tissue changes, such as circumscribed foci of tuberculosis in the lungs or elsewhere, emphysema of the lungs in a small degree, anthracosis, small ulcers in the stomach or intestines, and encysted degenerated parasitic cysts in such tissues as the liver. Would it be right to call this man healthy during the period of his lifetime when he harboured the lesions, although they produced no distinct outward signs of ill-health. The skilled worker trained to examine people in the *postmortem* room would say "no;" he would declare that the subject was not normal or was abnormal, meaning thereby, he would not expect to discover such lesions in men who are perfectly healthy.

Now, the above examples are quite sufficient to explain the hesitancy of the mind versed in matters concerning disease in furnishing a definition. We have said that the expression disease evokes in the lay mind a series of pictures or mental associations. What the term implies is exactly the same to the trained worker as to the layman, but the former is able to express himself regarding the difficulty of furnishing a precise definition, while to the latter the term is more or less self-evident.

The difficulty resides in the fact that disease is a conception; it is subjective and not objective; it is something which is relative and not absolute; it is not a concrete object. It is a term which evokes mental associations or pictures connected with the state or states of an object rather than an idea of something tangible. A lesion such as is understood by a pathologist is not a conception; it is something tangible; for example, the lesion known as a tubercle caused by the tubercle bacillus is something tangible, and can be measured or weighed. But disease is something which cannot be measured by common standards of measurements, but is simply estimated by a comparison with the picture formed in the mind of certain state, namely, of what one considers to be the usual or, in other words, the normal state of living individuals of the same class. Disease is therefore an abnormality, meaning thereby a deviation from the picture of the normal. It will be readily understood from the above introduction that an essential preliminary to the understanding of disease or disease processes is a mental grasp of the picture of the living subject in so-called health, both structurally and functionally.

Hygiene is a word employed to denote a study or pursuit connected with the health of the living man or animal. The word comes from the Greek *Hygeia*, the goddess of health, the daughter of *Aesculapius*, the god of healing. We may call hygiene the science of health, but even in such a small definition, there are elements of controversy: what is science and what is health? It has been explained that disease is a conception, and so is likewise health. It refers to a living individual who lives the life of an average or normal individual of his species or class. This statement connotes ability to perform the functions of the average members of that class, such as for example, the special work of the class. This, again, implies that he is capable of producing, for himself and his dependents, sufficient energy and utilize it to maintain himself and them in the state which is demanded of him by his environment or society.

Again, it may be debated that hygiene is not a "science." For, science means knowledge and not necessarily the application of knowledge, which is denoted by the term "art.' It can be argued that the object of hygiene is not so much to study the condition of the living body in health but rather to apply the knowledge available from other sciences to promote health. The argument is really of little importance except that reflection upon this point will serve to indicate how vastly far-reaching, all-important, and all-embracing is the study known as hygiene. If one takes it to be a science, then the important sciences known as physiology, pathology, bacteriology, helminthology, and others are simply to be included as parts of the science of hygiene. If one takes it to be an art, then the knowledge required must necessarily be derived from all these sciences, which become as it were the handmaidens of hygiene. Having now accepted health and disease as relative terms or concepts, we must proceed further to analyse the factors upon which each state is dependent. It will be readily seen that the terms life and death are concepts of the same order, except that the relativity associated with these concepts is perhaps not

of such magnitude. It is obvious that the limitation of any factor which makes for health will tend to produce disease.

After consideration of the above illustrations, it will be seen that for purposes of convenience in discussion the various factors which influence health, or a limitation of which tends to produce disease, may be grouped very roughly under the following headings :—

1. Air.
2. Water.
3. Food.
4. Temperature.
5. Accommodation or " room."
6. Freedom from injury.

Deprivation, unsuitability, or insufficiency of any of the above factors is injurious ; excess may also be injurious.

What is termed the maintenance of health may be deemed equivalent to prevention of disease. Hence, an alternative name that can justly be applied to the term hygiene is " preventive medicine," and in order to obtain a clear grasp of the field that interests us, it is well to regard these terms as synonymous. However, in current language during recent years the term " preventive medicine" has come to mean something a little different from hygiene, for, specific diseases are generally dealt with more particularly in works purporting to deal with "preventive medicine," whereas the general prevention of all diseases and the maintenance of fitness as by proper ventilation, water supply, and dietetics are dealt with in works allocated to hygiene. Again, another term which might rightly be regarded as synonymous with hygiene is sanitation. Etymologically, the two words are synonymous, for, sanitation comes from the Latin word *Sanitas*, which also means health. However, in recent years, the term sanitation has come to mean more particularly the application of methods which have for their effect the elimination of any influences which may be injurious to health, such as for example, the removal of excreta, and what are termed nuisances by drainage or otherwise.

It is well now to contemplate what have been regarded as the main factors which make for the maintenance of health. The scope and significance of most of them are fairly obvious. But we shall see later that it is very difficult to break up the subject into chapters each of which will be separate and distinct and deal with merely the significance of a single factor. For example, in dealing with the influence of the air, or atmosphere, on the maintenance of health we would have to discuss the heat regulation of the body, which is again dependent on a supply of energy from the combustion of food (" dietetics ") and the loss of which from the body is influenced greatly by environmental conditions (" thermometrics," " hygrometrics," and, generally, " climatology," as well as the type of living accommodation). It will

be seen, too, that variations in these subsidiary factors render the living organism peculiarly susceptible to the last named factor, namely "injury." First of all, however, we must take into consideration very carefully the significance of factors such as air, water, and food, the influence of which is very obvious. It is well known that without a sufficiency of air, or, in other words, of oxygen, mammals such as men will succumb in about three minutes. There are also small quantities of substances in the air such as carbon dioxide gas which have a far-reaching effect upon the health of living subjects, particularly plants, which serve as foodstuffs for animal subjects. In connection with water, we must remember that the animal body is composed of 70 to 80 per cent. of water and that the substances required by the body cells for their nutriment are transported to them and the waste products of the body are all carried away from the body in solution in water. Moreover, evaporation of water from the body has a profound effect upon the regulation of the body temperature. We will also have to see in what way water or the so-called impurities of water may produce disease, and in this connection the significance of water in animal health may be quite different from that which it has in human hygiene. Food is something which, of all things, is that which is most sought for voluntarily by the living organism, although it may live on occasion without a supply of this factor for a much longer time (in the case of man, three months sometimes). Food supplies energy for the maintenance of the body, material for its growth, and also energy for the performance of the work. It is convenient to deal with temperature while discussing the limiting factors of air.

The factor of accommodation involves consideration of many important problems, for the animal organisms which we have to deal with specially are such as have now become adapted to a more or less forced or artificial mode of existence which we call domestication. In the case of a wild animal, it might be thought that one could have little to say in connection with this factor. But, if we take it to represent accommodation in its widest sense and to imply the environment of the animal, one can see that it is something which has a most important meaning. If we take, for example, certain kinds of cattle accustomed to live in the open and place them in different conditions of environment or accommodation, such as in the confined housing of dairy cattle, they may suffer adversely. In any case, one can readily say that in the case of man or most of his domesticated animals, the factor has a very direct economic bearing; for, a great part of the energy of man is devoted to the provision of housing or accommodation for himself and his animals which will be most conducive to their efficiency and feeling of well-being.

The last factor, namely, "freedom from injury" is, however, the one which occupies most attention in writings and discussions upon the prevention of disease, and, in fact, the terms "disease" and "injury" may be accepted as synonymous expressions after very little reflection. An injury is anything which produces harm or discomfort or death to the living being, and hence we may class the injuries to which the living being is susceptible according to the following manner, very roughly

but it must be remembered that they are only classified in this manner for the sake of convenience in illustration :—

1. *Gross injuries* (" *Traumatism* "), so-called accidents, and such as may be inflicted by enemies in the form of other living beings of large size, for example, attacks by wild animals.

2. *Intoxication* (" *Poisoning* "). One is tempted to differentiate poisoning due to obviously non-living substances such as arsenic, or strychnine, from the poisons which may be set up in the course of a disease caused by living organisms such as by certain bacteria (*Bacillus botulinus*, Gaertner's bacillus, the tetanus bacillus). But, in reality, there is no very sharp line of demarcation between the effects of the two kinds of poisoning.

3. *Injuries caused by other living organisms*, mostly very minute in size, and generally called " parasites." In the broad sense, the term parasite would include species of animals or plants comprised within a great number of the groups or divisions of the animal or vegetable kingdoms. If we look at the animal kingdom, we find that the organisms called parasites are represented widely among the Anthropoda (insects, ticks, and mites), Vermes (helminths), and the Protozoa. We have, therefore, in the animal kingdom, parasites which vary greatly in size. We might even include large animals which prey entirely on other animals in this category, and from animals of this size, we find ones of decreasing size down to those which require high powers of the microscope for their detection. In the vegetable kingdom, we have likewise representatives from the fungi (Hyphomycetes) and the lowest forms of what one may regard as fungi, namely, the Bacteria. If one includes plants which injure in virtue of containing an active poison when ingested, then one can see that there is great variation in size among the injurious organisms belonging to the vegetable kingdom. We have again minute parasites which cannot be readily placed in either of the animal or vegetable kingdoms, particularly, the Spirochaetes, or spirillary organisms, and again we know that disease is caused by living structures so minute that we have not been able to recognize them with certainty even with the highest powers of mic oscope (" ultra visible or filterable viruses "). The term " virus " and the term " parasite " are practically synonymous. In fact, the term virus was currently employed in the days before modern methods of study had revealed the exact causes of the most important diseases, and found them to be usually minute parasites (Bacteria or Protozoa). Much human reasoning had led to the belief that the causal agents of such diseases were in reality minute living beings, even before the microscope had demonstrated their true nature. The term is now reserved in exactly the same way only for those living agents which are so minute or elusive that we have not been able to demonstrate their structure, although we know quite well that they are living and that they cause disease. The study of the minute parasites which are responsible for disease is of very recent origin and may be said to date from the fundamental researches of Pasteur and Koch at the commencement of the latter half of the 19th century. When these pioneers

commenced their investigations of disease processes they found that the living beings responsible for some of the most serious diseases of men and animals proved to be minute living organisms classed as bacteria, and hence the pursuit of knowledge concerning disease with reference to its cause or origin came to be known for a number of years by the name Bacteriology, and this quite erroneously, for, we now realize the causal agents of disease are by no means confined to the bacteria, and again by no means all bacteria cause disease. In fact, the great majority of them play a fundamental part in the economy of the universe, and without them it is difficult to see how men or animals or plants could persist when we come to consider the important rôle played by them in the soil surface in enabling plants to acquire the chemical substances they require for their nutrition. A much more apt term would be Parasitology, but, through usage, this term has come to signify, again quite erroneously, the study of the grosser parasites, such as the arthropods and helminths, and this significance may be attributed to the wave of enthusiasm that prevailed, just over a century ago, in connection with the study of these parasites, which were then thought to be of about the limit in minuteness of living beings that were parasitic. In fact, Linnaeus in his great system of classification believed microscopic beings hardly worthy of considered study and he grouped them all together in one small genus. This enthusiasm died down with the advent of bacteriological study and investigators of diseases prided themselves in the new appellation of "bacteriologist;" for, it seemed to them that they placed themselves thereby in a more exclusive and erudite category than that to which the older parasitologists belonged.

We are now able to see, however, that bacteria are merely parasites like any other parasites, although they may be perhaps the most important parasites. But, still, we must regard them as parasites and take firmly into mind the conception that in the investigation of disease or the control of disease they fall into the category of living beings which may produce injury and are therefore parasites. And, in dealing with injuries caused by parasites, it is extremely important from the point of view of the hygienist or disease investigator to envisage the problem as a single one and consider not only the parasites but the reaction of the host to the parasite. Thus, he is concerned not so much with the zoological or botanical nature of parasites but with their offensive characters towards the subject whose health is his prime study and with the defensive powers which that subject already possesses or is capable of developing, perhaps with the aid of his intervention.

We may again divide the factors considered above, merely for the purposes of appreciating the interrelationships of health and disease, into two kinds, namely, (1) non-living environmental influences, and (2) living environmental influences. The division of the various influences that affect health in this way presumes that the maintenance of health is dependent upon a state of harmony between the living body and its environment; or, in other words, the production of disease is due to a rupture of the harmony between the living body and its environment. It does

not, however, much matter how one appreciates the several factors so long as one keeps in mind a clear and complete picture of the whole field to be considered, and notably the fact that in the picture of health one must envisage a state of complete harmony or balance between the living subject whose health is under study and the environment, with its contributing as well as its disturbing influences towards the maintenance of health.

In the study of hygiene of the animal body, it is usual to dwell upon the non-living or relatively inert factors at some length first of all, and this method is logical. But, when we come to consider any single factor, we find that it is so intermingled with the effects of other factors that one must take first of all a preliminary brief survey of the whole field. For example, when one has to study the effects of the air or atmosphere on the maintenance of health, one comes very soon to the point when one must analyse carefully what is meant by the popular term " vitiation," and in dealing with this point one cannot leave out of consideration the fact that there exists in the air a large number of minute living organisms the effects of which upon health may be deleterious. When we come to study the influences of the various kinds of minute living organisms that may be brought into association with the animal body, we have to recognize the possibilities sometimes of very beneficial effects as well as of injurious effects from their presence. For this reason, at the outset of the study, it is well to deal with a portion of the last factor enumerated above, namely, " Parasites and Parasitism," in order to obtain an understanding of the probable effects of the association of the living organism whose health we are considering with other organisms in the course of its existence.

The best method of appreciation of the great principles of hygiene is to take in mind a number of conspicuous and well studied examples. For the purpose of understanding the phenomenon of parasitism, we may take the following as illustrative and convenient examples of the association between two different living organisms, namely, a parasitic organism on the one hand and a host organism on the other.

(1) The anthrax bacillus and any susceptible host, such as the ox. If one takes blood from an ox that has died of anthrax, containing as it usually does large numbers of anthrax bacilli, and injects this blood into a susceptible ox, this animal dies very soon and in its blood one obtains, on microscopical examination, convincing evidence that there has been a tremendous multiplication of the bacilli injected into the system of the animal. The one organism, namely, the anthrax bacillus in developing, multiplying, and destroying the life of the other organism, namely, the ox, is, therefore, said to be a disease producer or, in technical language, a pathogenic, virulent organism for the ox. If one injects some of the blood instead into a common fowl the chances are that the fowl does not die, and if the blood of the fowl is examined at any time after the injection of the blood, one will not be able to discover in it any anthrax bacilli. The reverse phenomenon has here occurred. The one organism, namely, the fowl, has destroyed

the other organism, namely, the anthrax bacillus, by means of some influences residing within its body quite apart from its volition.

The above stated phenomena are by no means constant in occurrence. One knows that the vitality of the fowl can be depressed so that after it has been injected with the virulent anthrax material it will succumb to anthrax. Here, the anthrax bacillus has brought to a termination the existence of the fowl. Again, one can depress the vitality or, more strictly, the pathogenicity of the anthrax bacillus, as, for example, by cultivating it outside the body at unsuitable temperatures, so that it will not then produce death in the ox, but is destroyed in the tissues of the ox, and, moreover, the ox subsequently becomes highly resistant even to an attack by a virulent form of the anthrax bacillus, or, in other words, it has become immune. The fowl in the first place was naturally immune but, as we have seen, its resistance can be depressed, while the ox was naturally not immune, but an immunity can be conferred upon it artificially by the intervention of certain processes. It then developed what is known as an acquired immunity.

(2) The glanders bacillus and horses, mules, or asses on the one hand, and the glanders bacillus and cattle on the other hand. In the first kind of association, the glanders bacillus propagates at the expense of the health and eventually of the existence of the other organisms, the horse, mule and ass. In the second case, the glanders bacillus is destroyed whenever it attempts to invade the tissues of the ox and no adverse effects are produced on the ox unless one injects very large quantities of glanders bacilli into its veins.

(3) A trypanosome (*Trypanosoma evansi*—the cause of the disease known as Surra) and (*a*) the horse, (*b*) the camel, (*c*) the buffalo, and (*d*) the ox. Now, a strain of this trypanosome of moderate virulence, as one understands "virulence" in the light of what has been said regarding the anthrax bacillus with regard to the ox, will almost certainly kill (within a few days to few weeks) the horse, and, on the other hand, the chances are nearly as great that it will not kill the ox. The chances that it will kill the camel are variable and not so great as when it attacks the horse (about 80 per cent. after a much more prolonged interval). The chances that it will kill the buffalo are still less although greater than in the case of the ox. A curious fact, however, is ascertained very commonly if one takes a quantity of blood from the unaffected ox sometime (may be some years) after the injection, and injects this blood into an animal such as the horse or the dog which is very susceptible to invasion, disease, and death from the effects of the trypanosome. It will then be found after a few days that the horse or the dog will become sick ; on examination of their blood it will be found to be swarming with trypanosomes and it is very likely that the animal injected will die soon afterwards. This experience would prove that, in the blood of the ox, the trypanosome injected had persisted in a living state and maintained its character of pathogenicity for the most susceptible species of hosts. The trypanosome may, however, be so rare relatively in the blood of the ox that one would fail to detect it

even after prolonged search under the microscope. The phenomenon presented in this example is different therefore in at least one important feature from that presented by the first two examples. The invading organism having failed to kill the invaded animal multiplies only very slowly and lives in a state of more or less complete harmony with it. But, if by chance, it happens to gain access into the tissues of a more susceptible beast, it will multiply rapidly and probably kill the invaded host.

(4) The "red-water" piroplasm (*Piroplasma bigeminum*) and cattle. If the tick which carries the piroplasm from one ox to another and in which it develops during a certain phase of its life-history bites an adult ox which has not been invaded by this organism before, then the ox will develop fever in from 9 days to a little over a fortnight, and if one examines a suitably stained preparation of the ox's blood, one will find that quite a considerable proportion of the red cells of the blood are now invaded by the piroplasm. The red cells are, moreover, distorted in shape and unequal in size, and if one makes a count of them they are smaller in number than they are usually in the blood of a normal ox. Very soon the urine of the animal is deeply tinged with red, due to the presence of haemoglobin in solution. The haemoglobin represents the red colouring matter of the red cells which have been destroyed by the invasion with the piroplasms. Next, the animal may become more and more depressed in condition, until it dies.

Now, if the tick had however bitten, instead of an adult ox, a very young calf under six months old, the probability is that no symptoms of the disease would have been seen subsequently. In fact, the animal would probably maintain its normal appetite and grow in size and increase in weight without showing any visible disturbances due to its having been infected with the piroplasms. Nevertheless, the thermometer would probably indicate that the temperature of the animal had risen somewhat between the 9th and the 14th day after it had been bitten. For the rest of its life, this calf would probably never suffer from red-water even although it was reared in a locality where the ticks were notoriously infective and adult susceptible animals introduced into the locality succumbed to red-water. Again, an interesting thing would be discovered by a special examination of the calf's blood. If one were to take a small quantity of the blood and inject it into an adult animal that had never been infected with piroplasms, the result would be serious. The injected animal would more than likely develop fever, signs of so-called red-water, and large numbers of piroplasms would be discovered then in the red blood cells on microscopic examination. The calf had therefore not recovered from the effects of infection with the red-water piroplasms but for the rest of its life had tolerated the presence of the piroplasms in its blood stream in a state of subdued or latent activity. Again, if later in life, this calf were to become adversely affected in health by some other depressing condition, such as an attack of rinderpest, then it is very likely that if the attack of rinderpest were of such intensity that the animal might recover from the effects of this disease by itself, it would nevertheless develop serious and probably fatal symptoms of red-water, with the presence of large numbers of

the piroplasm in its red blood cells. The piroplasms which had lain in a dormant, subdued, or latent state had therefore become resuscitated in activity by the onset of the depressant condition, rinderpest, and they then acquired the property of multiplying to such an extent that they killed the invaded animal.

(5) " Coccidia " and rabbits or cattle. If one examines the fæces of most adult rabbits or cattle in India carefully one will find in them very rare minute round oval or ovoid protozoan organisms called coccidia. The adult animals seem to tolerate the presence of these organisms very well, and one cannot tell by looking at an adult rabbit or ox whether it is harbouring small numbers of coccidia in its bowels or not. Now, the general experience is that, if one endeavours to breed rabbits on a large scale in a state of captivity, then, sooner or later, the younger rabbits will show unthriftiness and probably diarrhœa. In time, this lack of complete health will become more and more manifest until the youngest rabbits born in the hutches will almost invariably succumb from the symptoms of intense diarrhœa and emaciation. If one examines samples of fæces from these young rabbits, one finds enormous numbers of coccidia in them and is justified in assuming that the intense multiplication of coccidia has been the cause of death in the young rabbits, whereas the old rabbits were able to maintain the coccidia in a state of very slow or subdued multiplication within their intestines.

Again, frequently, in the course of outbreaks of rinderpest, one notes that some of the cattle develop the typical picture of rinderpest in a mild form but in a week or two after the onset of first symptoms or a few days after the disappearance of the symptoms, when one expects the animal to have recovered from rinderpest and to be in a state of convalescence, it has what appears to be a relapse of symptoms, of a somewhat different order, however, to what one expects to see in typical uncomplicated rinderpest. The animal develops inappetence, has an unthrifty appearance, strains a little and sometimes at this stage one notices small clots of blood in the fæces, although the presence of these clots is by no means invariable. Then, it develops diarrhœa, often of a very watery character, sits down, or lies down prostrate on its side, exhausted and unable to get up, and dies. Examination of the fæces or of the contents of some portion of the cæcum or colon now would reveal enormous numbers of coccidia, in such numbers, in fact, that one is justified in assuming that the coccidia were the real cause of death although they were present in the intestines of the animal long before it developed symptoms, but at that time they were kept in a state of subdued or latent activity. The supervention of rinderpest, however, depressed the resistance of the ox's intestines to invasion to such an extent that they became the prey to rapid multiplication of the coccidia and this rapid multiplication caused the death of the animal.

Now, in this example, we see that the coccidia living within the rabbits are usually, we may say, normal organisms which resort to living in a state of harmony with the host organism, but in certain circumstances as when they have facilities for invading the bodies of rabbits presenting a much lower degree of resistance,

namely, young rabbits, they develop a degree of pathogenicity capable of causing serious harm to, or even the death of, the young rabbits.

In the ox, much the same conditions apply. Coccidia usually live in a state of balance or harmony with the ox but when the resistance of the ox is lowered as by rinderpest or when they invade young cattle first put on to pasture, they too develop a high degree of pathogenicity towards the organism in which they are settled.

(6) One of the best examples one can think of to illustrate an interdependence which is different from those recorded in the above examples is that seen in the group of plants known as the Orchidæ. In this group, it is well known that the seeds cannot germinate and the young plants attain maturity in a sterile soil. In fact, development does not take place unless the soil is infected with a certain fungus belonging to the group known as Mycorhiza. This fungus develops on the root terminals of the embryo and enables it to assimilate nutrient material from the soil. These plants are unable to assimilate their nutrients direct like the majority of other plants. A somewhat similar association is seen in the natural order Leguminosæ in which there are tubercles on the roots containing bacteria which possess the extraordinary property of being able to assimilate nitrogen direct from the air and elaborate it into nitrates, which serve for the nutrition of the host plant. Examples of this kind are not easy to find among the animal kingdom. A somewhat very similar one is to be found in the life-history of the tsetse-fly (Glossina). This fly lays its offspring in the form of fully grown pupæ in the interior of which there is a store of food material derived from the mother, chiefly, lipoids. The pupæ are quite unable to digest this food material but digestion is affected by the agency of living organisms, namely, yeasts, (Saccharomyces) present in the lipoid bodies.

(7) An example of an association closely resembling the mutually beneficent association recorded in the previous example is to be noted in connection with the great majority of the living organisms in the intestinal tract of healthy animals. We know that in the case of herbivora no digestive juices are secreted that are capable of dissolving the cellulose which forms often the great bulk of the food material of these animals. The digestion of cellulose is accomplished in the rumen of ruminants and the cæcum and colon of the Equidæ chiefly by the intervention of various micro-organisms, namely, bacteria and, perhaps, protozoa, so that the cellulose is broken down, energy in a small amount is liberated, and the digestion products are probably to some extent utilizable after assimilation. It has even been suggested that the bacteria flourish on the cellulose and that the protein of their bodies which has thus been elaborated may be utilized later by the animal itself for digestion and assimilation. In any case, if it were not for bacteria digesting the cellulose coats of the vegetable cells which contain the starch and other food materials of greatest use in the vegetable food, it would be difficult to see how these herbivorous animals could extract any appreciable nutriment from the kind of food which they ingest.

We know also that a large proportion of the contents of the large intestines in all animals is composed of living bacteria. In the carnivora, particularly, it has been estimated that fifty per cent. of the dry matter in the fæces is composed of bacteria. Studies of the bacterial flora of the digestive tract of children have shown that the presence almost exclusively of a certain type of bacteria namely, certain so-called lactic acid bacteria (*Bacillus bifidus*) is indicative of healthy functioning of the alimentary canal. If a breast-fed child is put on to another kind of food such as cow's milk, or artificially prepared foods, it often suffers considerable intestinal derangement, and if one now examines the fæces of the child, one finds that they contain not as before almost exclusively lactic acid bacteria but a very large percentage of coliform bacilli of various types and even other bacteria. The coliform bacilli are such as would not probably cause any derangement in the intestinal mucous membrane of adult human beings, but it is believed that many of them flourish in the deranged alimentary canal of the child or have attained a degree of virulence which is sufficient to affect deleteriously the less resistant intestinal mucosa of the young subject.

Other interesting examples could be readily furnished illustrating the extent of interdependence of two organisms when they live in close association. In literature, it has been usual to regard one organism which lives or preys upon another organism for its sustenance as a parasite and the organism preyed upon as the host. If, on the other hand, the two organisms live in association and the association is mutually beneficial, then one regards the phenomenon not as parasitism but what is known as symbiosis (when there is mutual benefit), or commensalism (when one of the associates is benefited without either benefit or injury to the other). The two states of parasitism and symbiosis, however, are really relative; they are not absolute. In the most striking case of symbiosis quoted, namely, that of the Orchidæ and the Mycorhiza, recent researches have shown that mutually advantageous interdependence is not achieved without a considerable degree of conflict. It has been shown that many seedlings succumb to the depredations of the initial infection of the rootlets with the fungus and that in many others there is pronounced evidence of a reaction on the part of the root tissues. When, however, the tissues overcome the initial tendency of the fungus to invade and destroy, the two organisms settle down to live in a state of balance or mutual harmony, the root contributing certain essential advantages to the fungus and the fungus perhaps contributing certain advantages to the higher plant.

When one comes to consider the examples afforded in the quoted examples of infection by coccidia and piroplasms, one sees that one has in them merely a variation in the picture presented by the associations of one organism with another as illustrated by the so-called symbiosis of Orchidæ and their root fungi. After the initial contest, if they have not destroyed the host the invading organisms settle down, one might say wisely, to living in a state of tranquility and much

curbed activity, especially in regard to reproduction, in the bodies of the larger organisms.

It has also been pointed out how the properties of the larger organisms, that is the hosts, to curb the activity of the smaller, invading organisms may be depressed. In the case of certain organisms such as that quoted in the first example, namely, that of anthrax, the invasion of the larger host would appear at first sight to be pursued uncurbed by any properties of the larger organism. On further examination, however, one can see that in these types of invasion the larger organisms make considerable effort to curb the extent of the invasion, for, in the case of invasion by the anthrax bacillus, one has merely to depress the properties of the parasite to invade, as by cultivating it in unsuitable media, and the host is then quite able to resist invasion by the organism of attenuated penetrating powers.

In the present state of our knowledge, therefore, one may hazard to generalize concerning the nature of disease, in so far as it is produced when it is caused by invasion with parasites, and it is this type of disease which is most often encountered when one comes to deal with the problems of preventive medicine. Generally, one may say that disease of this type is the outcome of a conflict between one organism and another, namely, the one whose health we have under consideration. Serious disease is caused when the invading organism, or parasite, multiplies seemingly unchecked in the important vital tissues of the invaded organisms, and the multiplication may proceed to such an extent or the invasion may affect tissues of such delicacy or of such importance in their relationship to the rest of the body that serious harm immediately results, or, again, they may excrete injurious poisons, so that the invaded animal will succumb and die. Although, in the dead organism, the multiplication of invading living organisms would appear to proceed unchecked, in the living organism the invasion is always checked or curbed and if the "machinery" for checking or curbing is effective, the invaded organism can recover from disease.

We have many interesting and important problems to consider in this phenomenon of "Parasites and Parasitism":—

(1) The systematic position of the parasites, either in the vegetable or animal kingdoms. A consideration of this aspect would involve a study of the sciences now known as Bacteriology, Mycology, Helminthology, Entomology and Protozoology, notably.

(2) The effects of parasitism on the parasite. In the evolution of a parasite, we find that its morphology often becomes profoundly altered. In some species, certain organs and tissues are greatly degenerated: for example, in the helminths, most organs are intensely degenerated and often unrecognizable, except the reproductive organs, which appear greatly hypertrophied as compared with similar organs in nearly related non-parasitic species. In other parasites, the morphology of certain organs especially would appear to be much developed, particularly in those organs which are mostly concerned with the parasitic habits of the organism. Thus, for

example, in many of the ectoparasites, such as the fleas, we have examples of a great development of certain organs.

It will be readily seen too, that in the development of the species of organisms which are recognized as highly injurious or pathogenic parasites, there is evidence of " unwisdom " or " incomplete understanding " on the part of the parasite as to the course that will eventually be most profitable to it, notably for the perpetuation of its kind. In the case of a very pathogenic parasite one can imagine that if it had ample opportunities for multiplying by depredations upon a particular host, this host would sooner or later become extinct, and also simultaneously the life of the parasite which had by then become an obligatory pathogenic parasite. If, on the other hand, the parasite were content to develop its powers of penetration only to such a degree that it could obtain sustenance from the host organism without limiting seriously its vitality and chances of survival, then it can be seen again quite readily that such a parasite might survive indefinitely. We have in the very good illustration of Orchidæ and Mycorhiza a visible demonstration of the validity of this hypothesis. Here, when the fungus kills the rootlets, it must of necessity perish too, unless there are other rootlets in the vicinity to infect. On the other hand, when the initial multiplication of the fungus is kept in check and curbed to such an extent that it subsequently multiplies very slowly on rootlets, the survival of the fungus may reasonably be assumed to stand a chance of being quite as prolonged at any rate as that which the orchids can achieve when they are given every other chance of survival.

Pathogenicity on the part of the parasite may therefore be regarded as evidence of incomplete adaptation. It is something which is detrimental not only to the host but also to the parasite. A good illustration is afforded by certain minute animal organisms (protozoa) that live in the bowels of man. Here, with the harmless amœba, *Entamœba coli*, which is content to live upon the food residues within the bowel, the chances of its survival are equal to those of the human race. On the other hand, in the case of the amœba living in man which sometimes develops very serious pathogenic properties by invading largely certain vital tissues, namely, *Entamœba histolytica*, the chances of prolonged survival are not nearly so great unless it becomes an organism of low or inappreciable pathogenicity. When this amœba multiplies rapidly as it does when it forms abscesses in the liver, the parasites then stand no chance of gaining access into the outside world to continue the existence of the species by feeding another host, no matter whether the original host survived or not as the result of the lesion produced. Again, when this amœba causes serious lesions in the mucous membrane of the bowel by its rapid multiplication, the progeny become excreted in the fæces before they have attained that stage of development which they must reach if they are to be in a position to infect another host.

If we revert to consider the phenomenon of animal trypanosomiasis again, we have a comparable picture when the trypanosomes are content to propagate alternately in biting flies such as tsetse-flies and what one regards as relatively in-

susceptible hosts, or "reservoirs," such as the wild game of the forests of Africa. When the trypanosomes propagate in this manner they may readily survive as long as there are flies and "reservoir" animals in the territory. When, however, the trypanosome lives alternately in what one calls a susceptible host such as a horse, one can perceive that if its powers of invasion were restricted to these hosts it would soon become extinct, for all horses in the territories in which it prevails would succumb to the infection.

(3) Effects of parasitism upon the host. In dealing with this aspect of parasitism, the best method of understanding its peculiarities is to take again some well known illustrations.

(*a*) The conflict between a virulent bacterium of the class known as pasteurella organisms, such as the causal germ of hæmorrhagic septicæmia in buffaloes and cattle, and (i) the guinea-pig and (ii) the rabbit.

If one injects under the skin of a guinea-pig a small quantity of an emulsion of culture of a recently isolated strain of this kind of pasteurella organism, one will note in a day or two the development of a tense, hot, painful swelling at the seat of inoculation. This swelling will increase in size in the course of the next few days and then become fluctuating in consistence; the skin over the swelling then ulcerates and a thick fluid known as pus escapes from the wound and is discharged for a day or two; the wound cavity then heals up, the swelling disappears, and probably the only effect of the invasion left will be a small scar at the seat of injection.

If a rabbit is injected, however, in the same manner, one will note the development of no swelling at the seat of injection and the rabbit very shortly (within a day or two) will develop very serious illness from which it usually succumbs.

Now, if one makes a fuller study of the reaction in the guinea-pig, one will understand why it is that this animal was able to survive after the invasion whereas the rabbit succumbs. There develops in the guinea-pig an intense local reaction or "inflammation." This reaction is manifested by the hurrying to the seat of the invasion of a large number of cells found normally in the blood stream (the so-called polymorphonuclear leucocytes). The function of these cells is revealed if one makes a microscopic examination of the exudate at the seat of reaction. Each leucocyte will then be found to engulf or ingest a number of the invading parasites, which later become digested and destroyed within the substance of the leucocytes. Moreover, one then finds that the connective tissue cells of the part, which have hitherto been dormant, become stimulated to a state of intense activity. Thus, one sees quite early in the part a very large number of mononuclear cells, mainly, the so-called fibroblasts, and later it will be noted that the layers of such cells more remote from the centre of the injury develop fibrils and, later still, well formed fibrous tissue. After the reaction has been in progress for some time, the centre of the injury becomes liquefied, the liquefaction extends until the overlying tissues ulcerate, and the harmful organisms are, then, in large part, extruded to the exterior. On the side nearest the animal body, a barrier of connective tissue is formed which

effectively walls off the injury from the rest of the body. As the injury diminishes in intensity, this wall retracts and the wound is filled up by a proliferation of the wall and a covering of the breach with ingrowing skin epithelium.

The above succession of changes are almost inappreciable in the rabbit; there is no marshalling of cells to the part the special function of which is to engulf or ingest invading organisms (phagocytosis), and there is no other form of barrier set up against a general invasion of the body.

One might be tempted, at first sight, to conclude that the rabbit sets up no defence against invasion; one has seen that the local defence at any rate is negligible or at least inadequate. On little further examination, one can see, however, that the rabbit does not become invaded as if it were a simple culture medium. If one makes a smear from the heart blood at the time of death and examines it microscopically, one will note that the smear contains usually a very large number of the invading micro-organisms, and a great many of these invaders are not free in the plasma, or blood liquid, but are found to be ingested by the leucocytes in the general circulation. Again, it will be noted that the animal develops a profound general reaction which is made very manifest by the increased body temperature, which, as is stated later, is an indication that the whole of the animal's tissues are being stimulated to work at a much higher tension than normally.

Now, even for the rabbits, the parasitism of the above invading organisms is by no means a constant or absolute property. As was demonstrated in the earliest researches of Pasteur, upon the properties of disease-producing organisms, it suffices to cultivate this type of invader in an artificial medium outside the animal body for a more or less prolonged period of time for it to lose its initial property of producing a severe disease and perhaps death in a susceptible animal. Moreover, in this early work of Pasteur it was proved that an animal which had been able to withstand the effects of invasion by the weakened or attenuated parasite was subsequently immune towards invasion of fully virulent organisms of the same type. The properties of so-called virulence on the part of the parasite and susceptibility on the part of the host are therefore clearly variable, and variation can be induced to a greater or less extent artificially.

(*b*) Cholera vibrios and guinea-pigs.

One may intervene upon the body of a guinea-pig by injecting it under the skin or into the peritoneal cavity with a quantity of an emulsion of cholera vibrios (the causal agents of Asiatic cholera in man) the vitality of which has just been destroyed by heating to a sufficiently high temperature. After having injected the guinea-pig with material treated in this way, one takes it again two or three weeks later and injects into its belly cavity living fully motile cholera vibrios; a fresh, untreated guinea-pig is also injected at the same time with the living germs in the same way. After the injection, one withdraws from the peritoneal cavity by means of a pipette at intervals of, say, about five minutes a drop or two of fluid from each guinea-pig. In the untreated guinea-pig, it will probably be noted that no profound change takes

place in the appearance of the vibrios : they remain separate and probably steadily multiply. In the treated guinea-pig, however, a few minutes after injection with living vibrios in the same manner, there will be noted a profound difference in the appearance of the vibrios ; they will no longer be motile and individually separate but most individuals will be collected into clumps and, later, these clumps will be found to increase in size. Afterwards, a change will be found soon to take place in the constitution in each individual vibrio ; first, they will be found to assume a granular appearance ; later, the granules will appear to become more distinct ; then, the envelope which surrounds the granules will be dissolved away so that instead of observing a mass of fully formed vibrios, one notices a mass of irregularly sized granules ; still later, all trace of granules even will disappear.

In the treated guinea-pig, the organisms have first of all become clumped (or agglutinated) and then dissolved (or lysed). Even before lysis has taken place the organisms on cultural examination will be found to be dead. In this very pronounced and readily observable reaction, it is not the body cells that take part in the process but some substance or property in the body fluid. One can further prove this if one were to take some of the blood serum of a treated guinea-pig and inject it simultaneously with the emulsion of vibrios into the peritoneal cavity of an untreated guinea-pig ; on examination of fluid withdrawn from the peritoneal cavity from time to time, the same phenomena, agglutination, bactericide, and bacteriolysis will be observed (Pfeiffer's reaction). If, on the other hand, one injects simultaneously with the emulsion of vibrios serum from an untreated guinea-pig the succession of phenomena will not be found to occur.

From the above examples, it will be seen that the living organism invaded by a parasite by no means acts towards the invasion as if it were a dead inert mass of nutrient material, but it always reacts to the invasion, and the reaction can be measured in terms of the local, or cellular, changes brought about subsequent to the invasion, or by the general reaction, manifested particularly by changes in the properties of the fluids of the body towards the invader after recovering from the invasion. What has been stated in regard to these reactions by no means exhausts what can be said regarding the living organism's capacity for defence. But it is sufficient in the way of an introduction so as to enable the reader to appreciate the several factors upon which health is dependent when we come to deal systematically or serially with the most important diseases of animals in the country and the principles upon which are based the methods suggested for combating them

THE CONTROL OF THE BIOLOGICAL FACTOR IN SOIL FERTILITY BY IRRIGATION.

BY

C. M. HUTCHINSON, C.I.E., B.A.,

Imperial Agricultural Bacteriologist.

Recent advances in our knowledge of the science of soil biology have led to the general conclusion that the relationship between soil fertility and the bacterial action upon which this depends, is mainly determined by the water supply in the soil. The aim, generally unconscious, of the cultivator in this respect is in most cases to secure nitrification of the organic nitrogenous matter either present in, or added to, the soil, and the measure of his success will depend upon the provision of appropriate moisture conditions for the various stages of the process. Under natural conditions, therefore, he is dependent firstly upon the amount, and, secondly, upon the incidence of the rainfall, and most of the management of the soil, in which the art of agriculture mainly consists, is directed towards making the most of such rainfall as occurs. In irrigated areas, however, the uncertainty attendant upon this natural water supply is to a large extent done away with, and it is therefore precisely in such districts that we have an opportunity, not only of making use of such knowledge as we possess of the water requirements of soil bacteria, but of adding enormously to our, at present, comparatively scanty stock of information on this point. The gap in our information comes at present between our knowledge gained in the laboratory and the conditions obtaining in the field, and it is this gap which research, carried out under proper conditions, should be able to fill. The necessary conditions, in my opinion, would involve the close collaboration of an experienced laboratory worker (a soil bacteriologist) and an agricultural expert fully experienced in irrigation methods, and the chances of successful and rapid advance in this line of research would be greatly increased by the inclusion in this collaboration of a soil physicist on the one hand and probably an irrigation engineer on the other.

The importance of this line of research is overwhelmingly great ; it may be partly gauged from the large volume of discussion ranging round about such subjects as soil aeration, drainage, and irrigation, and based almost entirely on empirical experiment or mere dogmatic statements of the water requirements or air requirements of crops. Of real knowledge, even of optima, we have at present but little, and although research on soil biology is continually adding to it, such advance is necessarily slow, very largely on account of the small number of centres where such research is being carried out, and the small number of workers on the subject. In

India we are especially well situated for such work in respect of the high soil temperature obtaining in most districts, with the consequent greatly increased rate and amount of bacterial action going on in the soil ; in addition to this we have enormous irrigation areas where knowledge of the optimal conditions of soil moisture is of incalculable importance because of the possibility of approximating to them by means within direct control.

Not only is it of great importance to know how best to secure nitrification of organic nitrogen present in the soil, but the actual increase in the amount of the latter by natural fixation processes may be said to be of equal consequence, especially in India. There can be no doubt that such processes, whether symbiotic or asymbiotic, depend largely upon proper water conditions being maintained in the soil, and I am at present of opinion that the amount of nitrogen fixed by a soil is largely determined, *coeteris paribus*, not so much by the amount of water in the soil as by its continuous movement therein. In any case it is of prime importance to ascertain, as nearly as possible, the optimal methods of applying water to a soil so as to secure nitrogen fixation therein, as, in practically every Indian soil with which I am acquainted, the supply of nitrogen and the exhaustion of that supply by overcropping or intensive cultivation, is the most important problem to be dealt with. It may be of interest to mention here some of the particular problems arising out of investigations dealing with the relation between bacterial action and water supply in soils.

(*a*) In the conversion of buried organic matter such as green manures, oilcake, etc., into available plant food, the various stages of decomposition are carried out by different classes of bacteria requiring different soil conditions for their successful operation. Thus during the earliest stage when it is advantageous to provide for the breaking down of the cell walls of the vegetable tissues present, a high moisture percentage will conduce to completeness of this action ; later, ammonification is promoted by a smaller amount of soil water, and lastly nitrification of the ammonia and amino acids will be secured by a still further reduction of the water supply. Such control as this implies could only be secured under irrigation, although a well-distributed rainfall would produce similar results. In the above operation it is necessary for success to avoid certain extremes, such as the loss of nitrogen as gas under excessive flooding, the formation of soil colloids due to prolonged high moisture conditions, and the reduction of nitrates during the later stages due to the same cause. It is obvious not only that further research is necessary to determine more fully the conditions underlying such results, but to apply the knowledge gained to soils of varying type. It is also obvious that at present we are not possessed of sufficient information to lay down any hard and fast rules as to the number of waterings which will give the best results for any particular crop or

soil. It has been demonstrated at Pusa that the transpiration requirements of various crops may be modified by adequate provision of plant food ; such provision is partly dependent upon bacterial action, so that proper control of the water supply not only implies provision of the minimum requirement of the crop, but the possibility of reducing this amount by proper attention to that of the soil bacteria.

(*b*) In unirrigated soils of the Gangetic alluvium the growth of cold weather crops is sometimes considerably prejudiced by the undue concentration of nitrates in the surface layer, leading to the formation of a highly superficial root system incapable in many cases of obtaining sufficient moisture from the subsoil to secure complete growth. In Pusa soil this phenomenon is sometimes so marked as to lead to the concentration in the first inch of soil of over 90 per cent. of the total nitrate nitrogen in the first eighteen inches, with the result that careful cultivation is necessary to avoid the formation of a highly superficial root system in the *rabi* crop. With irrigation it is possible to keep down the nitrate to a suitable level and to secure its more even distribution, but it will be necessary to make careful experiments in order to determine the best manner of securing this result, without incurring the danger either of removing the nitrate out of root range or of promoting its reduction by bacteria.

(*c*) An interesting case in point is the practice, known in the Shahabad District as " Nigar," of running off the water from the rice fields some time before maturation of the crop ; it appears probable that this method results in the formation of nitrates which are supposed to conduce to proper ripening of this crop although fatal in the earlier stages. This case is cited as one of many which proper investigation would help to place on a sound basis of scientifically ascertained fact. In this connection it may be pointed out that problems of great economic importance are connected with the irrigation of rice, and should be included in any scheme of scientific investigation of the biology of soil under irrigation.

In considering the possibilities of controlling nitrification by suitable irrigation practice it is important to realize the fact that the amount of nitrate actually accumulating in a soil is the algebraic sum of two opposite sets of bacterial processes, namely, those producing nitrate as their end reaction and those either preventing the nitrification of nitrogenous organic matter or reducing nitrate already formed. The balance of these opposite processes is largely determined by moisture conditions in the soil, and so irrigation practice must be regulated in accordance with the information on this point obtained by biological investigation. Furthermore, the importance of such regulation lies not so much in the ability to produce large total amounts of nitrate during the season, but in the possibility of ensuring their

presence in sufficient quantity at definite points in the growing period of the crop. It is well known to agriculturists that the success of a crop so far as nitrogen supply can secure it, depends upon such supply being present in an available form at certain stages of growth. It is obvious therefore that incalculable advantage must accrue from the combination of knowledge of how to obtain and regulate this supply of nitrate and the power of doing so. It is such knowledge as this that can be obtained by researches in soil biology as applied to irrigation practice.

It may then be emphasized that an investigation into methods of irrigation, if it is to have any chance of providing really fundamental information, must include, and indeed mainly depend upon, research into the biological conditions obtaining in the soil.

SOME ASPECTS OF THE UTILIZATION OF THE UNDERGROUND WATER OF INDIA.

BY

G. S. HENDERSON, N.D.A., N.D.D.,

Imperial Agriculturist.

THE utilization of the underground water is one of the very important problems which is being dealt with by most of the Provincial Agricultural Departments in India. Most provinces have well boring sections which are busy sinking small-bore tube wells in the lands of small cultivators for irrigation purpose. This is the most important form of the utilization of underground water. Some 16,000,000 acres of cultivation are reported to be dependent on well irrigation.

Sir Alfred Chatterton in a recent paper on the above subject has drawn attention to the importance of " the millions of little patches of green cultivation to be found scattered over India in the hot weather in vivid contrast with the dark red or grey of the unirrigated soil."

Sir Alfred is not on such sound ground when he goes on to state that, as 6,000,000 cattle are required to work those wells, the cultivator has reached the limit of expansion with his present facilities, as the cattle eat an inordinately large share of the agricultural increment due to this labour. As an engineer he suggests that a patent new water-lift might be largely introduced and the place of cattle might be largely taken by small oil-engines.

This raises a number of interesting questions. There is little exact data regarding the " duty " of water, that is to say, information regarding the acreage of any crop brought to maturity by a cusec of water, and even less is known as to the optimum quantity of water to apply or the time of application.

In some parts of India such as Sind, there is practically no cultivation without irrigation, and all the intermediate graduations are found till in Assam, with a good and well distributed rainfall, there is no need for well irrigation.

Many wells are used as a protection in tracts of good rainfall or in extending the season before the rains begin or after they stop. These wells are not used during the rains. All these factors complicate the " duties " of well water in different parts of the country, quite independently of the varying water requirements of different classes of crops. Mr. Woods, late Chief Engineer, Punjab, stated " that the 16,000,000 acres of well-irrigated land would require 32,000 cusecs for 12 months," but to do this one cusec along with the natural rainfall would require to bring 250 acres of crop to maturity each 6 months and consequently the employment of 3,000,000

bullocks for watr-leifting. The writer of the paper mentioned puts 6,000,000 bullocks as being required, as he estimates that 64,000 cusecs are needed.

In the North-West, a canal outlet designed to give one cusec is generally allowed for 300 acres of land. The area of crop which is produced by one cusec is greatly increased when wheat and similar cold weather crops are grown, as two or three waterings are sufficient to bring wheat to maturity. This subject of duties of water or alternatively of the water requirements of crops is a very wide one,and due importance must be given to it in any irrigation schemes whether well or canal irrigation is contemplated. Very strong efforts were made by a committee under the presidency of Sir T. R. J. Ward, then Inspector-General of Irrigation, at the Poona Board of Agriculture in 1917 to get machinery started for systematic work to deal adequately with the subject, but little has been done since except isolated work by district irrigation engineers and agricultural officers and the specialized work near Poona under Mr. C. C. Inglis. Exact information is required for each tract as to the optimum amount of water required for each staple crop, and how in each district, given, say, a discharge of one cusec, this can be used with the greatest profit. Tube wells of 7″ to 15″ are being put down in various places fitted with strainer tubes, but the provision of the well is only the first part of the problem. A rotation suitable for the district must be evolved which will keep up the fertility of the land combined with a money making crop such as cotton, cane, tobacco, etc.

The second point to be considered is if the cattle population of India has reached a stage when it has become more than the crop production can support, and if in special the cattle used in water lifting are a large tax on the land. It seems to be the opinion of Sir Alfred Chatterton that cattle enter into competition with the human population for the foodstuff produce of the land. This view can hardly be supported if the facts are examined. At present work cattle are largely fed on by-products such as cotton seed, locally made oilcake and refuse from rice mills, etc. Cattle are an agricultural necessity in turning the production of the land into manure for which no artificial manure can be wholly substituted. India is a large exporter of grain, oil-seeds, cake and bones. Even if the cattle population of India were excessive, if a part of the oil-seeds annually exported were crushed in India and the cake fed to cattle and thus turned into manure, the country could support a vastly larger cattle population with resulting average increased crop production per acre.

Then comes the question, how far oil-engines, especially small power ones, are suitable for handling by even the wealthier cultivators? It is probable that the opinion of everyone who has had to do with cultivators in the East would be that any form of a steam engine is far easier and simpler to handle than any oil-engine, with inexpert labour. It is a great pity that efforts have not been made to produce a simple, cheap, portable engine of comparatively small horse power for agricultural purposes, which could also be easily converted to burn oil fuel. Steam engines for purely agricultural purposes are at a disadvantage in India as compared with oil-engines

on account of the Boiler Inspection Act. In the case of a factory an explosion is a serious matter and might mean loss of life to workers. In the case of a steam engine used solely for agricultural purpose and not housed, an accident would only affect the driver who could only cause an explosion by criminal carelessness. He might equally damage himself by working an oil-engine with a loose fly wheel; in fact, the writer has seen a driver badly hurt with a broken combustion tube while driving an oil-engine. In Egypt, steam engines are not inspected and they are very widely used for pumping on canals even though fuel is expensive. There is no doubt that the annual inspection of agriculturists' steam boilers is a distinct hardship, and if it has not been found necessary in other countries it is difficult to see why it should be necessary in India.

A very important matter was brought up by Mr. Woods and that is the effect of large tube wells on the local sub-soil water level. It is obvious that if a large tube well reduces the level of the sub-soil in its neighbourhood by giving a larger discharge then the sub-soil can supply, the amount of irrigation water made available will rapidly decrease. This is what has happened in the Amritsar scheme where batteries of tube wells are driven from a central power station. It also occurred in a similar scheme in the Fyoum in Egypt.

Mr. Woods states that one tube well per square mile with a discharge of two cusecs is the maximum consistent with a constant discharge. This is in a canal area; in non-canal areas pumping in the hot weather might possibly lower the water level so much as to reduce the well to inefficiency. It is an important matter which will have to be worked out for each district.

THE SOIL WITH SPECIAL REFERENCE TO SOME OF ITS INORGANIC CONSTITUENTS.*

BY

M. CARBERY, D.S.O., M.C., M.A., B.Sc.,

Agricultural Chemist to Government, Bengal.

FROM the earliest times till some sixty or seventy years ago agriculture was carried out by crude methods which had been handed down from father to son with little improvement. The latter half of last century, however, brought tremendous changes so that now agriculture is universally regarded as a science requiring all the skill and knowledge of a trained research worker to unravel the many factors affecting the production of crops.

The whole business of agriculture is founded on the soil, and on the skill in making use of its inherent capacities depends the outturn of crops which the cultivator will obtain.

The study of the soil and its function with relation to plant growth naturally, therefore, formed a starting point for the earlier investigators Many factors were found to enter into the problem, and of these not the least were the inorganic constituents which the plant required and abstracted from the soil. The more important are potash, phosphate, lime, and nitrogen, while to a much less extent sulphur, magnesium, manganese, iron, aluminium, etc., play some part. Thus one of the first means of studying the capabilities of a soil is to have a chemical analysis made of it to discover what amounts of inorganic plant food are present.

The value of these results, however, especially in India is apt to be over-estimated, for it has been found from practical experience that, because a soil possesses a sufficiency of one constituent, is no justification for saying that that substance should not be applied as a manure. While a sufficiency of plant food may be present in the soil it may not all be in a form which the plant can assimilate, and no really accurate method has yet been evolved to determine what percentage is readily available for plant food. Again it was originally thought that the plant absorbed the necessary substances in the form of a solution, but it is quite possible that colloids can pass through the cell wall, while it is also likely that salts in contact with the root hairs may be dissolved by the organic matter present in the latter.

Thus it will be seen that in this one function of the soil, *i.e.*, the supplying of inorganic plant food, the investigator is faced with a most intricate problem where

*Paper read at the Agricultural Section of the Indian Science Congress, Benares. 1925.

not only known but many undiscovered agents play a part—a problem amongst the most difficult that any scientist has to face.

If, then, we accept the theory that the plant feeds from a soil solution it must always be borne in mind that this so-called soil solution is continually changing, being considerably affected even by cultivation. Much more, then, will it change by the introduction of one or more of the necessary plant foods in the form of a chemical manure. A typical example of this is seen in the case of the red laterite soil round Dacca. This particular soil which is characteristic, in modified forms, of large tracts of Bengal is of a fairly acid nature containing large percentages of iron and aluminium with more than a sufficiency of potash.

It lacks, however, phosphate and nitrogen in sufficient quantities to produce crops which will pay for their cultivation. It was found that an addition of phosphate in the form of bone was very efficient, while liming was more or less a necessity. Difficulties soon arose, however, regarding the quantities to be used particularly of lime of which a fairly heavy dose was usually given to counteract the soil acidity, and after many field trials the Fibre Expert found that an application of potash to his jute produced very good results. This, however, did not agree with the chemical analyses which showed an ample supply of this plant food. Numerous experiments have now been conducted in the laboratory with results not only of interest but of economic importance. Thus it has been found that the application of increasing doses of lime means a corresponding decrease in available potash. Hence when the soil was heavily limed the potash available was insufficient for such a crop as jute, and so the results obtained by the application of potash to this crop are explained. Again to a lesser extent lime affected the phosphate in solution, so that here again a maximum point was reached - though much later than in the case of potash — after which an increase of lime meant a decrease of phosphate. Thus to put the results on an economic basis it would seem that the application of 10 mds. of lime per acre was ample though this quantity is far below that required to bring the soil to neutrality. Results in the field are corroborating these laboratory experiments ; while preliminary hydrogen-ion determinations on soils which have been treated with varying doses of lime over a number of years also point to the same economic result.

Many other points have arisen during these investigations, for instance, the quantity of iron was found to decrease considerably both through cultivation and the application of fertilizers. Again the quantities of water-soluble phosphate and potash fluctuate very considerably, and there seems here again to be a maximum, in some conditions in the case of phosphate at some three weeks after a bonemeal application. But this maximum is not stable either, as weather and other conditions must necessarily affect it.

Thus it will be seen that even in the investigation of some one or two plant foods in the soil, the worker is faced with many intricate difficulties, and even when some results have been obtained these have again got to be correlated with the crops

themselves where new factors and conditions come in, not the least of which is that different plants do not by any means require the same quantities of the various inorganic constituents. Other factors are organic matter in the soil, soil bacteria, temperature and moisture conditions, all of which play a definite part in the ultimate production of crops.

OUR EXPERIENCE IN CROSSING DIFFERENT VARIETIES OF RICE AT KARJAT.*

BY

R. K. BHIDE,

Crop Botanist to Government, Bombay.

THE percentage of successes in crossing flowers of different varieties of rice is rather small. From our two years' work in crossing at the Rice Breeding Station, Karjat, it may be attributed to the following reasons :—

(1) In rice the stigmas and pollen mature almost simultaneously and self-pollination is effected generally by the bursting of the anthers at the time of the opening or occasionally before the opening of the glumes, though in a very few cases of the flowers opening earlier in the day the anthers may emerge without bursting. This last might be due in certain cases to some defect in the anthers which contain rather unripe or moist pollen and thus remain yellow and unburst for a long time, or sometimes till they are quite dry.

(2) There seem to be slight differences in the time or temperature at which different varieties open their flowers. This makes it rather difficult to get ripe pollen just when it can be very successfully utilized.

(3) Cloudy or somewhat cooling conditions with or without rain, especially in the morning, result in some irregularity in the usual time of opening of the flowers. When the sun shines fitfully at intervals a number of flowers open at once ; but when the sunlight becomes dim owing to clouds further opening is suspended till the sun brightens up again.

(4) The glumes and rachis are very small and delicate for handling, and more or less injury to them may often be caused while opening the glumes artificially for emasculation and crossing.

(5) It is often difficult to emasculate the spikelets without causing the pollen to shed on the stigmas, and there is thus much waste of time, energy and material.

(6) It is somewhat difficult to know precisely the order in which the different flowers are likely to open.

(7) Wet, muddy and warm conditions in which the rice is grown are very unsuitable for easy work, and tax the patience of the operator.

* Paper read at the Botanical Section of the Indian Science Congress, Benares, 1925.

But above all the inexperience of the novice is the greatest cause of all failures. The following practical hints may, however, be useful :—

(1) At Karjat the opening of rice flowers begins at about 10 A.M. It is vigorous between 10-30 to 11 A.M. or so and may continue till 11-30 A.M. or 12 noon. The temperatures at which some of the early varieties open their flowers vary from 79° to 84° F., while the late varieties flower between 85° and 90° F.

(2) On the whole the flowering proceeds from above downwards, but a few of the uppermost spikelets (1 or 2) sometimes fail to open first, and probably do not form good grain also. Similarly there may also be slight irregularity in the order of opening of the lower flowers. But it seems that the flowers near the top of the panicle and those near the ends of the upper branches open first. Then follow the ones on the lower branches and their laterals in similar succession.

(3) To insure success in crossing the desired parents should be grown in convenient pots or low tubs and the pairs should be kept ready together, and even in the same pot if possible, properly labelled. If varieties flowering at quite different periods are intended to be crossed their sowing in the pots should be so adjusted as to make them flower about the same time. This can be done either by sowing the seeds at different times according to the difference in their flowering period, or by transplanting the seedlings of the early variety at two or three different times in one or more pots.

(4) The first and the most essential operation is to thin out some of the spikelets (the raw or poor looking ones) in the part of the panicle to be operated upon. This should be done about half an hour or so before the actual emasculation and the time of the normal opening of the flowers. It facilitates further operations better and causes no confusion at the critical time, which often spoils much of the work. For the same reason it is desirable to cut out those leaf tops also which are likely to interfere with the part to be operated upon.

(5) It is much better to take advantage of the naturally opening spikelets and to emasculate them carefully, since it can be done very easily in these, and without injuring the glumes or shedding the self pollen on the stigmas. Emasculation of such spikelets merely consists in removing gently all the six anthers with a fine pair of forceps while they are just beginning to emerge. Sometimes an anther or two remain behind caught up by the roof of the glumes and should be carefully scooped out with the point of the forceps, pushing the same from below upwards.

(6) However only a very few flowers open naturally without shedding the pollen on the stigmas and can be obtained at this stage. If any

spikelets are to be artificially opened for emasculation, injury to the basal parts of the glumes or even to their tips must be avoided as far as possible. Otherwise the glumes dry up and the ovary dries up too.

Cross-pollinating flowers in a potted plant.

(7) Only a few (2 or 3) spikelets at a time should be tried. These should be near the tip of the head or a branch, or just below the portion up to where flowering has already proceeded. The spikelets which are yet to flower can be distinguished from those which have already done so by the appearance of the unburst anthers through the semi-transparent glumes.

(8) One man should emasculate the flowers taking care to see with the help of a powerful lens that the stigmas of the emasculated flower do not hold any pollen grains. Another man who can read the labels should supply the pollen from the desired parent.

(9) In supplying the pollen of the desired variety such spikelets only as are either just opening, or immediately below the part of the head where the opening of flowers has proceeded, should be selected and cut with a fine scissors so as not to jerk them. If not already opening, the tips of their glumes should be separated so as to make room for the anthers to come out. With a little exposure to the sun they begin to come out and their tips begin to form slits. Such a spikelet should then be held top downwards immediately over the emasculated spikelet with the forceps, and the pollen supplier should be asked to give a gentle tap to the forceps with his scissors. In this way the pollen is shed easily and precisely on the stigmas of the emasculated flower. Just before doing so the tips of the glumes of the emasculated flower should be gently pushed apart with the two points of the forceps so as to make the stigmas protrude outside and to become exposed from the tangle of the antherless filaments.

(10) Pollen might also be shed on a clean and dry watch glass from such half-opened spikelets or from whole flowering parts of branches, if such spikelets are not available. From the watch glass it can be collected with the point of a pin and applied gently to the stigmas which can easily take it if the two are in the right condition. When the stigmas are receptive the stigmatic hairs are seen to be well spread out. But in raw flowers the hairs look somewhat shorter and not well spreading out. When the anthers are ripe they form slits at the tips on slight exposure to the sun and can easily shed the pollen through these slits with the slightest jerk.

(11) Emasculating the flowers too early is not good as then the stigmas are not ripe and receptive, ripe pollen is not available and the stigmas are likely to dry up. All flowers opening naturally early in the day should be taken advantage of if possible, but we cannot always be certain to get ripe pollen from the desired parent at this time. Later on most flowers that open naturally are generally self-pollinated. So such should be immediately cut off. A little practice will enable the

operator to know which flowers are likely to open early and which late or not at all on a given day. Those that are likely to open immediately show the anthers high up in the glumes. In the rest they are at or below the middle. Flattened and distorted or poor looking spikelets should always be rejected and cut off while thinning.

(12) It is not desirable to put the pots in the shade as there the flowers may not open naturally at the proper time. It is better to have a cooly to hold an umbrella over the operator's head so that while he is protected, the plants are in full sun.

(13) As regards the instruments required for crossing rice varieties, a powerful lens, two or three pairs of fine forceps, two or three pairs of fine pointed scissors, a watchglass, pins, labels, pencil, twine, thread, etc., are all the material that is needed.

(14) Protecting the flowers after crossing does not seem to be absolutely necessary, but small bags of stiff tissue paper might be used if desired. We have been sometimes using little rings of cycle valve tubing to hold the glumes in a closed condition, but in putting the rings much care is necessary; otherwise the glumes are likely to be injured or the rachis to break. If, while emasculating, the glumes have not received much injury, they generally close up within about an hour after pollination and can set good seed. But seed is also set sometimes even if the glumes are slightly injured at the tip or sides and remain open.

(15) If it is not desired to remove all the flowers on the lower part of the earhead it is at least necessary to separate the lower part from the upper by thinning a good bit of the middle portion fully and tying a thread in the middle to show the point up to where flowers have been crossed.

When this method is followed carefully we may be pretty sure of getting a tolerably high percentage of success (50 to 60 per cent).

Emasculating the flowers on the day previous to crossing by first clipping the tips of all the spikelets and shaking the earhead of the pollen parent over these spikelets on the next day has been recommended by some workers as giving a very high percentage of success. But we found it difficult to emasculate the flowers in this way owing to the small size of the spikelets of the varieties used by us. That method might probably be useful for coarser varieties, nor is that method said to give very well developed seed and for the proper germination of it further precautions also seem to be necessary.

By the method to which we have now settled we not only get a tolerably high percentage of success but the seed that is produced is also well developed and does not require any special precautions for its germination.

SELECTED ARTICLE

THE EFFECT OF GRASS ON TREES.*

BY

ALBERT HOWARD, C.I.E., M.A.,

Director of the Institute of Plant Industry, Indore, and Agricultural Adviser to States in Central India.

I. Introduction.

In the meadows and pastures of the temperate regions and the tropics, trees flourish when surrounded by communities of grasses and herbs. Such grassland is, with few exceptions, an artificial product, created by man from areas originally forest, and maintained in its present condition by such agencies as grazing, cropping, mowing and manuring. If left to themselves most of the meadows and pastures on the earth's surface would soon revert to the original forest, the rate depending on a number of circumstances, including the nature of the weapons possessed by the trees in suppressing the grasses and herbs. In the tropics, where pastures are much fewer than in the temperate zone, grassland after enclosure becomes covered by shrubs and trees with remarkable rapidity.[1]

Although trees soon oust grasses from the habitat under conditions of free competition, nevertheless cases occur in which grass is able to suppress certain species of trees. One such example has recently been investigated in great detail in Great Britain by the Duke of Bedford and the late Mr. S. U. Pickering.[2] At the Woburn Experiment Station fruit trees such as apples, pears, plums and cherries failed to flourish under grass on a heavy clay soil. Similar results have been obtained in the United States [3] and also on the Gangetic alluvium at Pusa.[4]

The cause of the injurious effect of grass on trees was attributed by the Duke of Bedford and Mr. Pickering to a soil toxin (produced by the growth of grass) which acted as a poison towards the roots of trees. This explanation of the action of grass

* Reprinted from *Proc. Royal Soc.*, Ser. B, Vol. 97, No. B 683.

[1] Warming, E. *Ecology of Plants*, Oxford, 1909.

[2] The Duke of Bedford and S. U. Pickering. *Science and Fruit Growing*, London, 1919.

[3] Hedrick, U. P. A comparison of Tillage and Sod Mulch in an Apple Orchard. *Bulls. 314, 375 and 383, New York Agri. Expt. Station*, 1909 and 1914.

[4] Howard, A., and Howard, G. L. C. Second Report on the Fruit Experiments at Pusa. *Bull. 16, Agri. Res. Inst. Pusa*, 1910.

presents a number of difficulties and has frequently been called into question. The soil toxin has not been isolated ; it was found to disappear in a very short time when the drainage water containing it was aerated. The injurious effect is not observed in an intense form in grass orchards on permeable, well-aerated soils ; while grasses and herbs are unable to maintain themselves against trees if free competition is permitted.[1]

The problem obviously needed further investigation and it appeared particularly desirable to repeat that portion of the Woburn work dealing with soil-aeration. Since 1914 the influence of grass on trees has been under investigation at the Pusa Research Institute. In this work two main problems have been kept in view, namely, (1) why grass is so injurious to fruit trees, and (2) the nature of the weapons by which forest trees vanquish grass.

1. *The factors.*

Soil. Pusa is situated in North Bihar, on the old alluvium of the Gangetic plain—formerly a great rift in the earth's crust between the Himalayas and the ancient formations of Peninsular India.[2] The country round is made up of low-lying rice areas alternating with broad, slightly raised ridges roughly parallel to the rivers, the differences in level rarely exceeding 10 feet. Trees occur only on the ridges, as the rice flats are inundated for long periods during the rains. The soil is a highly calcareous, silt-like loam containing about 75 per cent. of fine sand and silt and about 2 per cent. of clay. About 98 per cent. will pass through a sieve with 80 meshes to the linear inch. Stones and pebbles are absent, but are represented in the heavier soils and in the deep layers of fine sand by nodules of impure concretionary limestone (*kankar*). There is no line of demarcation between soil and sub-soil. The sub-soil resembles the soil and consists of alternating layers of clay and fine sand of varying thickness down to the sub-soil water which normally occurs about 20 feet from the surface. In the rice areas the soil is heavier and less permeable than on the ridges. The percentage of calcium carbonate is high —often over 30 per cent.—while the total phosphate is much below the average. Nevertheless, North Bihar is exceedingly fertile, maintaining a population of over 1,000 to the square mile and exporting large quantities of seeds, tobacco, cattle and surplus labour without the aid of any phosphatic manures. Two factors limit crop-production—shortage of organic matter and loss of permeability during the late rains. After the middle of the monsoon a colloidal condition of the soil develops ; the pore-spaces near the surface become

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[1] An interesting example of the result of free competition between grass and trees in the plains of India has recently occurred at Pusa. In June, 1918, a plot, 0·6 acre in area, was laid down in two coarse thatching grasses—*Imperata arundinacea*, Cyrill., and *Saccharum spontaneum*, L.—the two species being planted in separate strips. The grasses are cut every December. In spite of this, 594 trees (mostly *Dalbergia Sissoo*, Roxb.) established themselves by the end of 1922, when the area looked like a young plantation of forest trees. The trees had to be uprooted to save the grass.

[2] Burrard, S. G. The Plains of Northern India and their Relationship to the Himalaya Mountains. *Jour. and Proc. of the Asiatic Soc. of Bengal*, N. S., Vol. 12, p. xxx (1916).

waterlogged, and percolation stops. This condition interferes with aeration and must, therefore, exercise a profound influence on the flora and chemistry of the soil. The plant soon responds to the altered soil conditions. The absorbing roots in the lower layers die and the transpiration current is maintained by means of active roots in the upper few inches of soil.[1]

Food materials in the soil. The food material which is most frequently in defect is combined nitrogen, which is best added to the soil in the form of nitrifiable organic matter. The investigations of Leather,[2] Jatindra Nath Sen,[3] and Clarke [4] have shown that there are two periods when nitrification is active: (1) in the early rains during June and July, and (2) in October and November at the beginning of the cold season. These coincide with the active growth of the monsoon and cold-weather crops respectively.

Water. The average annual rainfall is 47·5 inches, most of which falls during the monsoon period (June 15 to October 15). After the rains, till the beginning of March, heavy dews are the rule and only a few minor falls of rain occur at the end of the year and during the hot season (March 15 to June 15). In addition to rain and dew, the soil itself acts as a vast reservoir of water and makes up for the uneven distribution of the rainfall. Except in the hot season, the surface soil is always sufficiently moist for growth, and the best cold-weather crops (like wheat) are obtained in years when no rain falls between sowing time and harvest. During this period (October 15 to March 15) a well-marked rise of moisture from the sub-soil water to the surface soil takes place.[5] The level of permanent water is met with at about 20 feet from the surface during the first six months of the year. It rapidly rises after the rains begin and comes to within a few feet from the surface in August and September, falling again after the monsoon. The total rise of the sub-soil water level in 1922 was 16 feet 6 inches (Plate XIV). This movement of the ground water ensures that the various soil strata are very thoroughly moistened and must also help in the distribution of soluble food materials, like nitrates, throughout the upper 20 feet of soil. The downward percolation of rain water after the early rains, immediately after one of the periods of intense nitrification, must also be an important factor in replenishing the nitrogen supply of the deep soil layers.

Temperature. The range of temperature throughout the year is shown in Plate XIV. Both the air and the soil temperatures begin to rise about the middle of February; after March 15th the rise is rapid and continues till the end of May.

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[1] Howard, A., and Howard, G. L. C. Some Aspects of the Indigo Industry in Bihar *Mem. of the Dept. of Agri. in India* (*Botanical Series*), Vol. XI, p 1 (1920).

[2] Leather, J. W. Records of Drainage in India. *Mem. of the Dept. of Agri. in India* (*Chemical Series*), Vol. II, p. 101 (1911).

[3] Sen, J. The Influence of Potsherds on Nitrification in the Gangetic Alluvium. *Jour. of Agri. Sc.*, Vol. IX, p. 32 (1918).

[4] Clarke, G. Nitrate Fluctuation in the Gangetic Alluvium and Some Aspects of the Nitrification Problem in India. *Agri. Jour. of India*, Vol. XVII, p. 463 (1922).

[5] Leake, H. M. Some Preliminary Notes on the Physical Properties of the Soils of the Ganges Valley, more especially in their Relation to Soil Moisture. *Jour. of Agri. Sc.*, Vol. I, p. 454 (1906).

The minimum soil temperature curve at 6 inches closely follows that of the corresponding air temperature, the only difference being that the temperature of the soil is about 6° F. above that of the air. Conversely, the maximum soil temperature at 6 inches is on the average 10° F. below the corresponding air temperature, except during the rains (June 15 to October 15) when the difference falls to 2° F. Contrary to expectation, the minimum temperature of the soil at 6 inches during the hot weather was not appreciably higher than that during the rains.

Humidity. The humidity of the air at 8 A.M. from the break of the rains in June till the end of February is high, varying from 80 to 90. A rapid fall takes place during March and April—in 1922 it fell to 47 (Plate XIV). The period of low humidity in these two months is caused by dry, westerly winds, which blow with great force and rapidly ripen off the cold-weather crops. During May, when the in-draught of moist air from the Bay of Bengal heralds the South-West monsoon, a rapid rise in humidity takes place, which continues till the next dry season begins.

2. *The growth of trees and grass at Pusa.*

Trees. The resting period of the majority of the trees met with in the Gangetic plain corresponds with the coldest period of the year—December and January—when the deciduous species drop their leaves. Flowering and the production of new leaves and shoots is the feature of the hot season (March to May), in spite of the simultaneous occurrence of several adverse factors—drought, low humidity and high winds. This is perhaps the most striking feature of the vegetation of North-West and Central India. At a time when the countryside is bare and parched, the trees suddenly burst into intense activity.[1] Another period of growth occurs during the early rains. In years of normal rainfall, growth slows down in August and September when the sub-soil water is high, but recommences in October and November after the rains as the water-table falls. In the case of deciduous species, this latter period is utilized for ripening the wood.

Grass. With one exception, the growth of grass corresponds generally with that of trees throughout the year. In the hot, dry months of March, April and May, grasses cease to grow and pass into a dormant condition, which ends abruptly with the first rains of June. During the hot weather, therefore, competition between grass and trees does not occur.

3. *The experimental fruit plot.*

In 1914, eight species of fruit trees were planted out in three acres of uniform land. Twenty-four trees of each kind, raised from a single parent, were set out 25 feet apart each way. The young trees were remarkably even and well-grown, and the plantation was an ideal one for experimental work. The following eight

[1] The flowering of trees in the dry season is universal in the periodically dry regions of the tropics and is discussed by Schimper in *Plant Geography*, p. 252 (1903).

species were selected for this investigation. The first three are deciduous, the remainder evergreen.

1. Plum (*Prunus communis*, Huds.)—budded on peach seedlings.
2. Peach (*Prunus persica*, Benth. and Hook., f.)—budded on seedling stocks.
3. Custard-apple (*Anona squamosa*, L.)—seedlings.
4. Guava (*Psidium Guyava*, L.)—grafted on seedling stocks.
5. Mango (*Mangifera indica*, L.)—grafted on seedling stocks.
6. Litchi (*Nephelium Litchi*, Camb.)—layers.
7. Sour lime (*Citrus medica*, L., var. *acida*, Brandis)—seedlings of the Sylhet variety.
8. Loquat (*Eriobotrya japonica*, Lindl.)—grafted on seedling stocks.

Two years after planting (1916), when the trees were fully established, a strip about the middle of the plot, comprising nine trees of each of the eight species, was laid down to grass—a pure culture of one species, *Cynodon dactylon*, Pers. The two end plots, which were kept cultivated and free from weeds, served as controls. Three years after planting (1917), when the grass was well established and its injurious effect on the young trees was clearly marked, the three southern trees of the grass plot were provided with aeration trenches, 18 inches wide and 21 inches deep, filled with broken bricks. Three trenches were made at equal distances between the lines of trees. The experiment has been continued till the time of writing (January, 1924) without any change as far as the plots under grass, under grass with aeration trenches, and under clean cultivation are concerned. One slight modification only was introduced in 1921. To ascertain the effect of grass on established trees in full bearing, the southern strip of the northern control plot has been grassed over since August, 1921. The plan (Fig. 1) will make the arrangement clear.

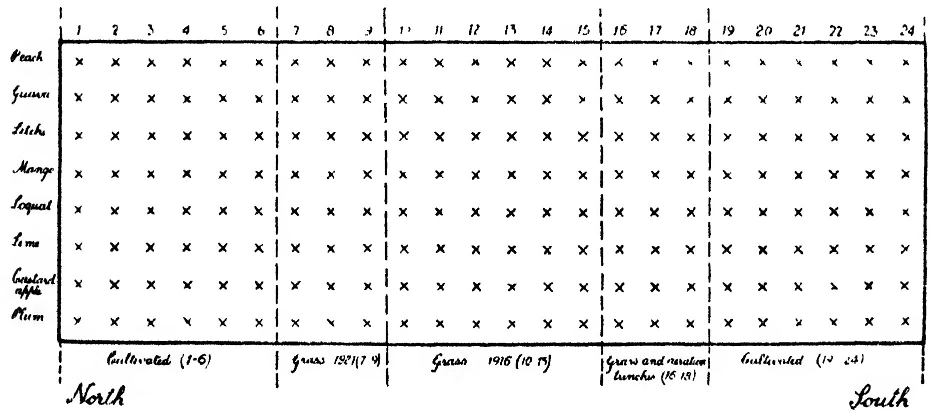

FIG. 1. Plan of experimental fruit area, Pusa.

The harmful effect of grass on fruit trees at Pusa is even more intense than on clay soils like those of Woburn in Great Britain. Several species are destroyed altogether within a few years. As great differences in root development were observed between the trees under grass, under grass with aeration trenches, and under clean cultivation, the first step in investigating the causes of the harmful effect of grass appeared to be a systematic exploration of the root-system (under clean cultivation), so as to establish the general facts of distribution, to ascertain the regions of root activity throughout the year, and to correlate this information with the growth of the above-ground portion of the trees. The detailed examination of the roots of the eight species was carried out during 1921, and the work was repeated in 1922 and again in 1923.* Although it has proved a laborious undertaking, the results obtained are both interesting in themselves and have been invaluable in unravelling the direct and indirect effects of the grass. They also throw light on questions of adaptation, and bear out Tansley's suggestion (*Jour. of Ecology,* Vol. IV, p. 54, 1916) that the real solution of the problem of adaptation to environment will be obtained only when the extent and character of both the absorbing and the transpiring organs of plants are studied and correlated.

II. The root-systems of fruit trees under clean cultivation.

The root-systems of three deciduous trees—the Plum, the Peach and the Custard-apple—have been studied under clean cultivation.

1. *Plum.*

The local variety of plum drops its leaves in November and flowers profusely in February and March. The fruit ripens in early May, the hottest period of the year. New shoots are produced during the hot weather and early rains.

The root-system is extensive and appears at first to be entirely superficial and to consist of many large, freely-branching roots running more or less parallel to the surface in the upper 18 inches of soil. Further exploration disclosed a second root-system. From the under side of the large surface roots, smaller members are given off which grow vertically downwards to about 16 feet from the surface. These break up into many branches in the deep layers of moist fine sand, just above the

* In the silt-like soils of the plains the 'knapsack sprayer' is of great use in exposing the fine ramifications of the root-system, and in determining where and to what extent the formation of absorbing roots is taking place. This device also gives valuable information on the texture of the soil. When the tilth is good, as in the surface soil and in the deep layers of fine sand, the soil is rapidly removed by the spray as a muddy stream. When the soil is stiff and percolation slow, the earth comes away much more slowly in irregular lumps in a comparatively clear stream of water. This method gives much more significant information with regard to soil texture than a mechanical analysis of the soil.

water-table. The plum has, therefore, two root-systems - a well-developed superficial system in the surface soil and a set of whip-like roots, which at first grow vertically downwards and then branch in the layers just above the level of permanent water (Plate XV, fig. 1).

During the resting period (December and January) occasional absorbing roots occur on the superficial system. When flowering begins, the formation of new rootlets spreads to the deep soil layers. As the surface soil dries in March, the active roots on the superficial system turn brown and die, and this portion passes into a dormant condition. From the middle of March to the break of the rains in June, root absorption is confined entirely to the deeper layers of soil. Thus, on April 14, 1921, when the trees were ripening their fruit and making new growth during a period of intense heat and dryness, most of the water and minerals necessary for growth were absorbed from a layer of moist fine sand lying between 10 feet 6 inches and 15 feet below the surface. This state of affairs continues till the break of the rains in June when a sudden change takes place. The moistening of the surface soil rapidly brings the superficial root-system into intense activity. These roots literally break out into new active rootlets in all directions, the process beginning about 30 hours after the first fall of rain. In the early monsoon, therefore, the trees use the whole of the root-system both superficial and deep. A change takes place during late July as the level of the ground water rises. In early August active roots are practically confined to the upper 2 feet of soil, and it is very rare to find even one below this zone. Absorption is now confined to the surface system. At this period, the active roots exhibit marked aerotropism, growing towards the surface and even out of the soil into the air, particularly under the shade of the trees and where the soil is covered by a layer of dead leaves (Plate XV, fig. 3). This continues till early October, when the growth above ground stops and the trees ripen their wood preparatory to leaf-fall and the winter rest. During October, as the level of the ground water falls there is some renewal of root activity near the surface and down to 3 feet.

One interesting exception to this periodicity in the root activity of the plum occurs. Falls of rain, nearly an inch in amount, sometimes occur during the hot season. The effect on the superficial root-system of the plum of three of these storms was investigated. When the rainfall was 0·75 of an inch or more, the surface roots at once responded and produced a multitude of new absorbing roots. As the soil dried, these ceased to function and died. In one case, when the rainfall was only 0·23 inch, no effect was produced. Irrigation during the hot weather acts in a similar manner to these sudden falls of rain. It maintains the surface root-system in action during this period, and explains why irrigation during the hot months is necessary on the alluvium if fruit of really good quality is to be obtained. It is true that without artificial watering the trees ripen a crop at Pusa, but in size and quality the produce is greatly inferior to that obtained with the help of irrigation.

During 1921-23, twelve exposures of the root-system of the plum were made, the details of which are given below :—

Resting period and hot weather.

February 17, 1921. Root-system exposed to 27 inches. Active roots were found between 4 inches and 16 inches but not below this point.

March 23-26, 1921. Roots exposed down to 15 feet—the upper 3 feet 2 inches very dry ; yellow clay 5 feet to 7 feet ; blue clay, 7 feet to 8 feet 6 inches ; yellow clay, 8 feet 6 inches to 10 feet 6 inches ; sandy loam, 10 feet 6 inches to 12 feet 9 inches ; fine sand containing concretionary limestone, 12 feet 9 inches to 15 feet 2 inches. The first active roots were found at 5 feet 6 inches. At 6 feet 9 inches there was extensive root-development in a small tunnel about 1·5 cm. in diameter, but no active roots were found here. One active root was observed at 7 feet in blue clay. Below 10 feet 6 inches the root followed began to branch freely in the fine sand. New recently-formed absorbing roots with abundant root-hairs were found from 11 feet 7 inches to 14 feet. Below this to 15 feet 2 inches the roots were still dormant.

March 9-10, 1922. The deep roots were exposed to 11 feet in order to determine at what time they become active. The first active roots were found at 7 feet, more at 7 feet 3 inches and at 7 feet 9 inches in sand. At 8 feet the sand changed to clay. At 8 feet 8 inches in stiff clay young roots were noted in two places and again at 11 feet in clay. In all cases, the new roots had been formed recently, some indeed were only just beginning. In 1922, therefore, the deep root system came into action a little in advance of the hot season

January 24-25, 1923. This exposure was made just before the buds began to swell. Active roots were abundant from 2 inches to 4 inches. Some new roots were observed at 1 foot, 1 foot 8 inches, 1 foot 10 inches, 2 feet and 3 feet 3 inches. Below this an interesting observation was made. After the heavy rains of 1922, five of the deep roots followed had died at 3 feet 8 inches, 2 feet 6 inches, 3 feet 8 inches, 3 feet 10 inches and 4 feet 4 inches from the surface. Just above the decayed portions, repair was in rapid progress and new vigorously growing roots 16·8 inches, 5 inches and 2·4 inches in length were observed. None of the mature deep roots were found alive below 4 feet 4 inches, but repair was in active progress at a time when the above ground portion of the tree was in resting condition. The heavy monsoon of 1922 led to a considerable rise of the subsoil water level. This in turn destroyed for a time the deep-root system of this tree. On August 3, 1923, another portion of the same tree was exposed. The repair of the deep-root system had proceeded considerably and the new branches given off just above the points of decay had reached 7 feet 3 inches and 9 feet 4 inches from the surface (Plate XV, fig. 2).

May 23 *and June* 9, 1923. The surface roots were exposed down to 2 feet on May 23, 28 hours after rain (0·72 inch) started and 24 hours after the fall ended.

New absorbing roots were just beginning. On June 9, another exposure of the surface roots of the same tree showed that the absorbing roots which started on May 23 had ceased to grow and were beginning to dry up.

Break of the rains in June.

June 5-9, 1922. This exposure to 12 feet 6 inches was started 40 hours after the break of the rains (June 3-5) after a total fall of 3·16 inches which saturated the upper 1 foot 8 inches of soil. From 1 foot 8 inches to 3 feet 8 inches the soil was dry, below which it was distinctly moist. Yellow clay occurred from 5 feet to 8 feet, then a layer of blue clay to 10 feet 6 inches followed by fine sand. On June 5, the surface system from 3 inches to 18 inches was breaking out into numerous new roots, the longest of which was 0·5 cm. They were more numerous near the surface and decreased in number downwards. By June 9, the development of new roots on the surface system reached its maximum. Everywhere the root system had burst into a myriad of new roots. A few new roots were found at 3 feet, 3 feet 4 inches, 4 feet, 8 feet 6 inches, 9 feet 3 inches and 10 feet. Below this to 12 feet 4 inches in sand, the number of active roots was large. Thus during the early rains the whole of the root system of the tree is in action.

June 26, 1923. The surface system was exposed at 8 A.M., 12 hours after the monsoon started. By 8 A.M. on June 25, 1·1 inches had fallen. New absorbing roots were just visible to the naked eye at 6 inches from the surface.

Second half of the monsoon.

August 25, 1921. Many active roots were noticed from 1 inch to 8 inches. A deep root was followed to 5 feet 6 inches. Two absorbing roots were found at 2 feet 7 inches, but below this to 5 feet 6 inches no active roots were observed.

August 12, 1922. Many active roots were observed from the surface to 2 feet 1 inch, but below this point only one new root—at 1 feet 2 inches—was found. At this time the absorbing roots were showing marked aerotropism, many were growing towards the surface and some were found on the surface under the trees. One new root, beginning at a point 1 foot 3 inches below the surface, grew almost vertically to 3 inches below the ground, giving off many new rootlets in the last six inches (Plate XV, fig. 3).

After the rains to the fall of the leaves in December.

November 6-9, 1922. A few new roots noticed in the upper 3 inches. They became more numerous between 2 feet and 3 feet 1 inches. No active roots were found below this point.

2. *Peach.*

In the peach, which flowers in February and ripens its fruits in May, results similar to the plum were obtained in 1921, 1922, and again in 1923. Seven exposures

in all were made. The distribution of the superficial and deep roots as well as the periodicity of root activity throughout the year agreed closely with the plum. The deep roots of the peach were followed to 15 feet 6 inches on two occasions.

3. *Custard-apple.*

The custard-apple sheds its leaves from December to February and the trees come into new leaf in March. Flowers appear towards the end of March, and by the hot weather the trees are in full foliage and also make considerable growth. The fruit ripens in August and September.

The root-system of the custard-apple is very similar to that of the plum and the peach. The extensive superficial roots give off whip-like branches which grow vertically downwards to the deep soil layers. In the twelve exposures made, the periodicity of root activity was found to be very like that of the plum. In the hot weather, the trees use the deep roots only and exhibit a marked reaction to any improvement in the aeration of the soil. On one occasion (April 12, 1921) at 5 feet 3 inches below the surface, a tunnel made by small black ants (*Monomorium indicum*, Forel, and *Acantholepis frauenfeldi*, Mayr., var. *bipartita*, Smith) was filled with a strand of fresh white roots, which gave out many lateral rootlets, covered with root hairs, into the surrounding earth. On another occasion (April 21, 1921) the deep root followed passed from clay into fine sand--12 feet 1 inch to 14 feet 1 inch. The amount of branching and the number of active roots showed a remarkable increase in the sand layer. The rains at once bring the surface system into action, and in August and September all except the roots close to the surface are dormant. The gradual resumption of root activity in the deeper soil layers after the fall of the sub-soil water in October and November was very clearly observed in this tree in 1922 and 1923. On August 10, 1922, the whole of the root-system was dormant, except that in the upper foot of soil. On December 8, 1922, root activity had extended to 5 feet 7 inches from the surface, but not below this point. At the end of January, 1923, it had reached 6 feet 3 inches, but below this point the roots were still dormant. By the middle of March, 1923, the whole of the deep roots were active.

After the break of the rains, the above-ground growth of the custard-apple becomes more rapid. The leaves increase in size (from $5{\cdot}8 \times 2{\cdot}6$ cm. to $10{\cdot}5 \times 4{\cdot}5$ cm.), take on a deeper green and the internodes lengthen (Fig. 2). These striking differences in size and colour between the leaves formed in the hot weather and those in the early rains are of interest in connection with the nitrogen supply. The leaves formed in the early rains, when both nitrification and root activity are proceeding in the surface soil, are large and dark green. In the hot weather, only the deep roots (from 10 to 15 feet below the surface) are active. The smaller size and the lighter green colour of the leaves of the hot-weather period suggest a shortage of combined nitrogen in these deep layers compared with that in the surface soil in the early rains. The custard-apple is its own soil analyst and records the results on almost every twig.

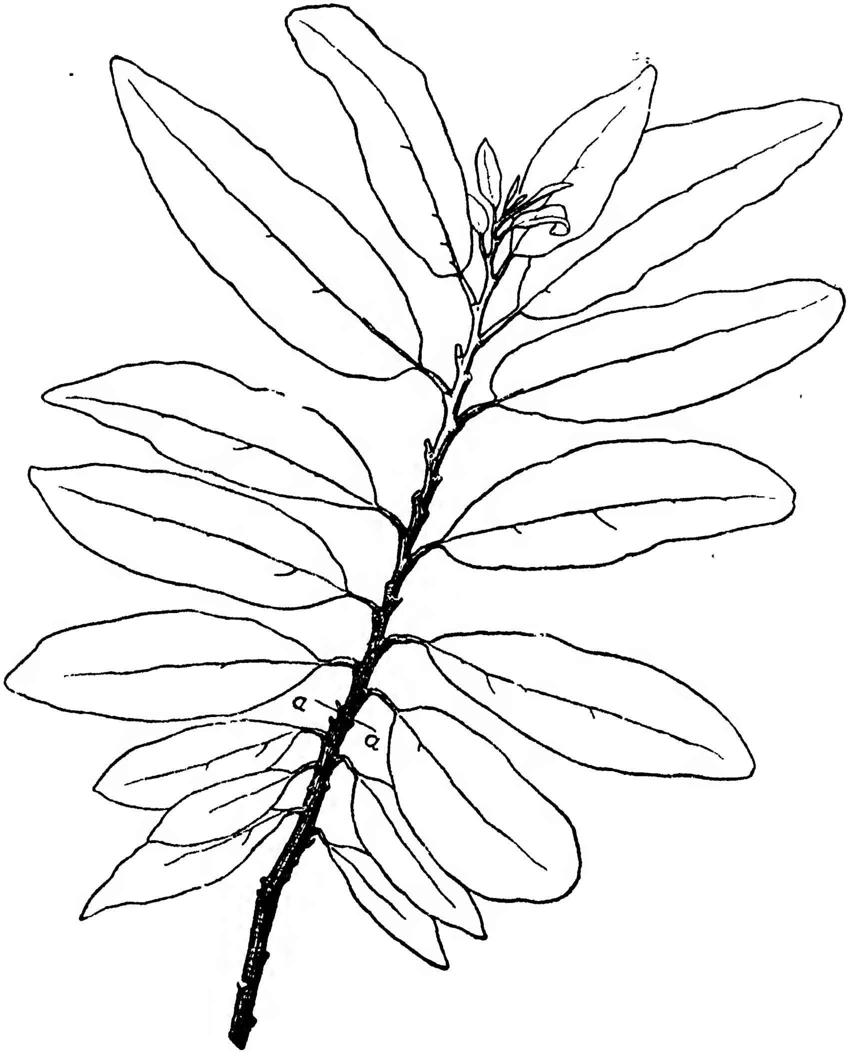

FIG. 2. Hot weather (below aa) and monsoon foliage (above aa) of the custard-apple.

The root systems, as well as the periodicity in root activity, of the following evergreens—Mango, Guava, Litchi, Sour Lime and Loquat—were also studied in detail.

4. *Mango.*

Flowers are formed in February and early March, after which new shoots are produced. The fruit is ripe in the early rains. The trees make the last new growth of the year in October, after which a short resting period occurs.

The nature and distribution of the root system of this evergreen, as well as the periodicity of root development, resemble in many respects those of the three deciduous species already described. The large superficial roots give off smaller branches to the deep soil layers (followed in 1921 to 15 feet 6 inches) which alone maintain growth in the hot season (Plate XVI, fig. 1). The early rains at once bring the surface roots into action. In August the deep system is dormant. The gradual downward development of root activity after the rains has been observed in the mango on several occasions. On October 22, 1921, absorbing rootlets were not found below 3 feet 8 inches, although the exposure was continued to 13 feet and two trees were explored. The next year (1922) an exposure was made a month later—on November 23. Root activity had proceeded as far as 4 feet 6 inches from the surface, but below this point the roots were dormant. At the end of January, 1923, when the flower buds were beginning to swell, root activity had reached 7 feet 9 inches. By March 10, 1923, at the beginning of the hot season, the lower roots were active down to 15 feet 6 inches.

The mango makes the fullest use of any cavities which exist in the deep soil layers, as a result of the activities of *Termites* or other burrowing insects and of the decay of roots. There is always an extensive development of fine roots with abundant bristly, reddish root hairs in such cavities, even in the deep sand layers. This suggests that in the hot season, when the texture and the aeration of the soil are at their best, the roots of this tree experience difficulties in obtaining sufficient oxygen. In August, the surface roots exhibit marked aerotropism and often grow out into the air in the circle shaded by the branches (Plate XVI, fig. 3).

The details relating to the ten exposures of the root-system, made during 1921-23, are given below :—

Flowering period and hot season.

March 10, 1921. A complete exposure to 15 feet 6 inches was made during the flowering period. The layers of soil passed through were ordinary loam to 6 feet 6 inches ; clay to 10 feet 6 inches ; sand to 12 feet 7 inches ; sand with concretionary limestone to 15 feet 6 inches ; and then yellow clay. New active roots were found from the surface to 15 feet 6 inches. The root hairs of the mango are short, stiff and dark reddish brown in colour, and do not readily decay.

March 9-10, 1922. New active roots at 1 foot 9 inches, 2 feet 10 inches, 4 feet, at 5 feet 2 inches in a cavity in a sand layer, and again at 7 feet, where the exposure stopped.

The break of the rains in June.

June 5 *and* 9, 1922. The rains started on the afternoon of June 3, and by June 5, 3·46 inches had fallen. The surface system was still dormant on June 5. On June 9 new roots were abundant, the longest being 1 cm.

June 27, 1923. Many new roots found at 5 inches. This year the rains started on June 24, and the first falls amounted to 1·1 inches by 8 A.M. on June 25.

Second half of the rainy season.

August 14-22, 1921. Many aerotropic active roots in the upper 12 inches of soil, new roots growing horizontally at 20 inches, going downwards at 26 inches and 30 inches. One new root at 4 feet 4 inches, two at 4 feet 9 inches. Below this no more new roots were found. In 1921 the rainfall was below the average.

August 15, 1922. An exposure was made down to 44 inches. New roots were abundant in the upper 6 inches, but none were found below this point. A year of normal rainfall.

After the rains to the resting period.

October 22-24, 1921. A complete exposure down to 13 feet after the fall of the ground water. The following strata were passed through: Ordinary loam to 3 feet 9 inches; yellow clay to 6 feet 10 inches; moist clay to 7 feet 7 inches; blue clay to 9 feet 8 inches; yellow clay to 10 feet 4 inches; sandy soil to 13 feet, when the exposure stopped. Active roots were noticed at 1·5, 3, 4, 5, 7 and 13 inches. Between 26 and 44 inches twenty-five newly-formed roots were observed (Plate XVI, fig. 4). Below 44 inches down to 13 feet the root-system was dormant.

October 23, 1921. Surface roots examined in greater detail in the neighbouring tree which was forming the last flush of the season. Many active roots in the upper 10 inches. At 10 inches many new roots growing towards the surface. Many of the fairly recent and still fresh roots, running about 4 inches below the surface, had sent up freely branching rootlets practically to the surface. The roots were followed to 12 feet 9 inches in sand, but no active roots were found in the deeper layers (Plate XVI, fig. 1). At 10 feet 7 inches in sand an empty cavity left by *Termites* was discovered filled with fine dead roots still covered with root hairs.

November 22-24, 1922. Many active roots between 2 inches and 6 inches. Many thin and three thick new roots found between 3 inches and 4 inches; eight thick new roots at 4 feet and 4 feet 6 inches. No new roots found below this.

January 27—*February* 2, 1923. Flower buds swelling. Exposure made to 11 feet. New roots found at 4 inches, one at 2 feet 10 inches, many at 4 feet 10 inches and a few at various depths down to 7 feet. From this point to 11 feet the root-system was dormant.

5. *Guava.*

The guava loses its foliage in early March, simultaneously producing new leaves. It is an excellent plant for the study of the root-system. The reddish roots are

very strongly developed and are easily followed in the light grey soil. In all, seven complete exposures of the root-system were made during 1921-23. There is an abundant superficial system which gives off numerous branches which grow vertically downwards to the level of permanent water (Plate XVII, fig. 1). As in the plum, peach and custard-apple, the whole of the root-system (superficial and deep) was found to be active at the beginning of the hot weather (March 21, 1921). The chief zone of activity at this time was, however, a moist layer of fine sand (10 feet 4 inches to 14 feet 7 inches) underneath a thick band of clay. On March 29, 1921, the influence of the soil texture on root development was observed. A root was being followed which was growing vertically downwards through a layer of the blue clay (7 feet 6 inches to 10 feet 3 inches). In the clay, the root gave off very few branches and no active rootlets could be found. As, however, it passed into the moist sand layer below 10 feet 3 inches, a sudden change took place. The root was literally covered with new growth (Plate XVII, fig. 2). As the hot season becomes established, the absorbing roots of the guava near the surface dry up and root activity is confined to the deepeer layers of soil. A change takes place as the rains break in June. In 1922, the monsoon started on June 3. An exposure of the surface roots was made on June 5—forty-eight hours after the rains started. From 1·5 inches to 12 inches, new roots were found in large numbers, the longest measuring 1 cm. The exposure continued to 12 feet 6 inches. After the first foot of soil, where the formation of new roots was intense, the next active roots were met with at 4 feet 3 inches and again at 6 feet 8 inches, after which they were numerous down to 12 feet 6 inches. At this time a dormant zone of over 3 feet in thickness occurred between the activity in the surface foot of moist soil and that in the deeper layers. As the soil becomes moistened by the early rains, this dormant zone disappears and the whole root-system becomes active. A change takes place after July. On August 15, 1922, it was found that root activity was mainly confined to the surface system in the upper 29 inches of soil. Below this, down to 40 inches, activity fell off, the last active root found occurring at 40 inches. At this time the deep root-system was entirely dormant. In the late rains the active roots are strongly aerotropic and grow right up to the surface (Plate XVII, fig. 4). An interesting change takes place after the level of the sub-soil water falls in October and the aeration of the lower soil layers is renewed. The deep root-system again becomes active in November, the degree of activity depending on the monsoon rainfall (Plate XVII, fig. 5). In 1921 (a year of short rainfall when the rise of the ground water was very small) the deep roots came into activity in November even below the water-level at 15 feet 3 inches. The next year—November, 1922—when the monsoon and the rise of the ground-water were both normal, root activity did not extend below 5 feet 7 inches.

Although the guava is able to make new growth during the hot season by means of its deep root-system it is a decided advantage if the surface roots are maintained in action by means of irrigation. Irrigation in the hot weather of 1921 increased the size of the leaves from $9{\cdot}1 \times 4{\cdot}0$ cm. to $11{\cdot}6 \times 5{\cdot}0$ cm. and greatly improved their colour.

6. *Litchi.*

This tree does not rest in the cold season. New growth begins in December, flowering takes place in February and the fruit ripens in May. Nine exposures of the root-system of this tree were made. As in the mango, the extensive superficial roots give off branches which pass down into the deep soil layers. The deep root-system, however, is not so strongly developed as in the mango and the guava, and only on one occasion—when they reached 12 feet 6 inches—have these roots been traced below 9 feet. This fact helps to explain the distribution of this tree in the Gangetic plain. It is only found in localities where the ground water is comparatively near the surface and where the soil moisture conditions are far above the average. The tree maintains itself by means of its deep roots during the hot season, and established plants ripen abundant crops of fruit without irrigation. At the break of the rains the surface system (dormant during the dry season) comes into action, as in the case of all the other trees examined. The monsoon started on June 3 in 1922, and shortly afterwards one of the trees was exposed down to 12 feet 6 inches from the surface. On June 5 many new roots, the longest 1 cm. in length, were found in the upper 18 inches of soil. Below this there was a layer of dry soil to 4 feet in which all the roots were dormant. A few active roots occurred at 4 feet 3 inches. Between 6 feet 8 inches and 12 feet 6 inches the whole of the deep system was active. Soon after the rains begin the roots of the litchi near the surface show marked aerotropism. Excellent examples were observed on August 9, 1921 (Plate XVIII, fig. 8), and again on June 15, 1922. After the rains the deep system again becomes active and before flowering begins the whole of the deep roots form fresh rootlets.

7. *Lime.*

The root-system of this tree has been exposed on eight occasions during the last three years. The nature and distribution of the roots as well as the periodicity in root-development closely follow that observed in the litchi, but with one important exception. The deep root-system is even less well developed than that of the litchi and the lower roots show a marked aversion to the layers of blue clay which occurred below the trees at a depth of 6 feet 7 inches. Although a deep layer of moist sand is met with below this clay at about 10 feet, not a single root reached the sand layer. They all stopped in the clay. The lime was the only species examined which failed to utilize the deep sand layers which occur at about 10 feet below the surface.

8. *Loquat.*

This species flowers twice a year—in August and again in January and February. Only the latter flowers set fruit, which ripens late in March when the hot season is well established. New growth accompanies and follows the spring flowering. Nine complete exposures of the root-system have been made since the beginning of 1921. The loquat has two root-systems and the periodicity of root activity closely resem-

bles that of the mango. The deep roots, which have been followed on several occasions to 16 feet from the surface, are active in the hot weather and maintain the trees during this period. The surface system (dormant in the dry season) is activated in the usual manner by the early rains. On August 13, 1922, in a year of normal rainfall, root absorption was confined to the upper 5 inches of the soil and the roots then showed marked aerotropism. A similar observation was made on August 3, 1923, when aerotropic roots were observed to have reached to within half an inch of the surface from a point about 6 inches deep. After the rains root activity spreads to the deep system, the rate depending on the rainfall. Thus on November 11, 1921, after a somewhat short monsoon (41·36 inches) a complete exposure was made to the water-level at 14 feet 8 inches. New active roots were found from the surface to 12 feet 2 inches. From this point to 15 feet 9 inches (a foot below the water-level) new roots were just being formed. On November 4, 1922, after a normal monsoon rainfall a similar exposure was made. New roots were found down to 5 feet 1 inch, but below this the deep root-system was still dormant.

The development of the deep root-system begins soon after the young trees are planted out. In August, 1923, the root-systems of young custard-apples, mangoes, guavas, limes and loquats, planted in March, 1922, were examined. In all cases, the superficial roots were well developed, and from these young vertical roots were being given off. They varied in length from 10 inches in the custard-apple and lime, to 1 foot in the mango, 1 foot 2·5 inches in the guava, and 1 foot 8 inches in the loquat. The newly planted trees form the superficial system first of all, followed rapidly by the deep system. This explains why it is necessary on the alluvium to irrigate newly planted fruit trees during the hot weather for the first two or three years. Afterwards, the trees are able, by means of the deep root-system, to grow during the dry season without assistance.

III. The injurious effect of grass on fruit trees.

The harmful effect of grass on fruit trees at Pusa varies with the species, and with the period in the life of the tree when the grass is planted. Young trees are more adversely affected than fully developed individuals, which contain large quantities of reserves. Deciduous species suffer more than evergreens.

1. *The effect of grass on young trees.*

The custard-apple is the most sensitive of the young trees studied. The trees were killed within two years after the grass was planted (1916). Next in order of susceptibility are, the loquat, plum and lime, all of which were killed by grass. The loquats died before the end of 1919, the plums by the end of 1921, and the limes by the end of 1922. Only four species have been able to survive under grass, namely

the peach, litchi, mango, and guava (most resistant). The peaches (of which four are dead and two have died back almost entirely) probably owe their existence to the fact that the trees were somewhat large and had come into bearing before the grass was planted. The litchis, except two trees which died in 1921, have made little growth and are only just able to maintain themselves. The mangoes have done better. Five out of the six trees are alive, the sixth having died in 1921, as a result of the exposure of the deep root-system during the hot weather. The guava is by far the least affected, the trees under grass being almost half the height of those under clean cultivation.

In addition to restricting the amount of growth, grass affects the leaves, branches, old wood and fruit, as well as the root-system. The results relating to the above ground portion of the trees closely follow those described by the Woburn investigators. Compared with the foliage produced under clean cultivation, the leaves from the trees under grass appear later, are smaller, yellower and fall prematurely (Plate XVI, figs. 5 and 6). The internodes are short. The bark of the twigs is light coloured, dull and unhealthy, and quite different from that of healthy trees. The bark of the old wood has a similar appearance and attracts lichens and algæ to a much greater extent than that of the cultivated trees. The trees under grass flower late and sparingly. The fruit is small, tough, very highly coloured, and ripens earlier than the normal.

The effect of grass on the root-system is equally striking. This has been investigated in great detail throughout the year and a large number of exposures have been made since November, 1920. It will be convenient to contrast the results obtained with the normal root-development under clean cultivation.

Except in the guava, the effect of the grass covering on the superficial system is to restrict greatly the total amount of root-development, to force the roots downwards below the grass (Plate XVIII, figs. 1 and 4), and to reduce very markedly the number of active rootlets during the monsoon. The most striking feature is undoubtedly the small number and poor development of the active rootlets during the rains compared with the enormous production of absorbing roots under clean cultivation. The guava, however, is an exception. The surface system is well developed, the roots are not driven downwards by the grass, while active rootlets are readily formed in the upper four inches of soil soon after the rains begin, very much as in the cultivated trees. In August, 1922, when the ground-water had risen to about its highest point, the absorbing roots of the guava were found in the surface film of soil, and also above the surface among the stems of the grass.

The grass covering has no appreciable effect either on the development or on the activity of the deep roots. This portion of the root-system was explored during the hot weather of 1921 in the case of the guava, mango and litchi, and results were obtained very similar to those in the corresponding cultivated trees (Plate XVII, figs. 2 and 3). In the guava, the deep roots were followed from near the surface, to 15 feet 9 inches. Active roots began to appear at 3 feet 5 inches, and were particularly

abundant in a layer of moist fine sand between 12 feet 8 inches and 15 feet 9 inches. In the litchi, similar results were obtained. The deep roots reached 9 feet 8 inches from the surface, and many absorbing rootlets were found between 8 feet 2 inches and 9 feet 8 inches in somewhat clayey soil. It was observed that the deep root followed had died between 5 feet and 6 feet, but had been replaced by a new branch just above the point of decay. In the mango, an exposure on April 11, 1921, down to 17 feet 4 inches from the surface, yielded somewhat similar results. In this case, however, the main tap root provided the deep root-system, as the surface roots were small and poorly developed. Active roots were not found till a fine sand layer (12 feet 10 inches to 17 feet 4 inches) was reached, where they were very numerous (Plate XVI, fig. 2). A cavity 14 inches long and about 1 inch in diameter was met with between 14 feet 6 inches and 15 feet 8 inches, filled with a network of absorbing roots covered with root hairs. When this exposure was made, the average length of the new shoots was just over 4 inches, the water and minerals for which were largely absorbed from a fine sand layer more than 12 feet below the surface.

Grass not only affects the roots underneath but also the development of those of the neighbouring trees under cultivation. Such roots either turn away from the grass, as in the custard-apple (Plate XVIII, fig. 2) or else turn sharply downwards before they reach it. In none of the cases examined did the roots from the trees under cultivation behave normally when they approached the zone occupied by the grass roots. They always avoided it.

Two conclusions can be drawn from these root exposures. In the first place, trees under grass are able to form the deep root-system and to make use of the moisture and minerals in the lower soil layers, as in the case of trees under clean cultivation. In the second place (except in the case of the guava) trees under grass form a very weak superficial system and produce but few active rootlets in the surface soil. The contrast between the trees under cultivation in this respect is very striking and significant.

2. *The effect of grass on established trees.*

The harmful effect of grass on established trees, which have reached their full development, has been studied in considerable detail. The damage is less marked than in the case of young trees, but the order of susceptibility is very much the same in the two cases. When the fully grown trees were put under grass in August, 1921, the grass at first grew poorly and formed tufts with bare ground between. Even this imperfect covering affected the custard-apples, loquats, peaches and litchis. By the rains of 1922 the grass was continuous all over the plot and no bare patches were visible. As soon as the carpet was complete the effect on the trees became much more marked.

In June and July, 1922, the growth of the new shoots of the plum was arrested and the foliage was attacked by leaf-destroying insects, which, however, ignored

the leaves of the neighbouring cultivated plot. In January, 1923, the average length of the new wood on these trees was 1 foot 5 inches compared with 3 feet 7 inches on the controls. The twigs were dull and purplish, the internodes were short (Plate XV, figs. 4 and 5). In February, 1923, flowering was restricted, and in April only tufts of leaves were formed at the end of the branches (Plate XV, figs. 6-9). At the time of writing, the damage is increasing and a great deal of die-back is taking place.

In the peach, the effect of grass became marked in July, 1922, when the leaves were yellower and fewer than in the controls. In 1923 the fruits on these trees ripened early, and in June of this year the average size of the leaves was $9{\cdot}7\times3{\cdot}0$ cm., compared with $12\times3{\cdot}8$ cm. in the controls.

In the custard-apples, the damage done by grass has been greater than in any of the other trees. The first effects were observed in December, 1921. In 1922 the buds opened late, the leaves were small and yellow, and the trees shed their leaves before those of the cultivated plot began to change colour. A good deal of die-back began in 1922 which rapidly increased in 1923. In July, 1923, the leaves formed during the rains, although larger than those of the hot weather period, nevertheless were much smaller, and the internodes were shorter than those of the cultivated plot.

The mango has so far resisted grass better than any of the other trees. No definite effect was observed till June, 1923, when the foliage was distinctly lighter in colour than that of the cultivated trees.

Similar results were at first obtained in the lime. The first definite change appeared in the early rains of 1923, when the leaves were smaller ($6{\cdot}8\times3{\cdot}3$ cm. compared with $8{\cdot}1\times3{\cdot}9$ cm.) and yellower than the controls, and when die-back began to appear. During the last six months the amount of die-back has rapidly increased and the effect of the grass is now pronounced (January, 1924).

The litchis, which began to show the effect of grass in December, 1921, showed little further change during 1922. In 1923, however, the effect was rapid. The fruit produced was smaller, less sweet, earlier and more highly coloured than that of the controls. In June, 1923, the leaves are much yellower, growth has been arrested and the trees now look much smaller than the controls.

The effect of the grass on the loquats has rapidly increased since December, 1921, when it first became evident. In June, 1923, the average size of the leaves had fallen to $21{\cdot}9\times7{\cdot}5$ cm., compared with $25{\cdot}4\times8{\cdot}9$ cm. in the controls. By December, 1923, the trees lost nearly all their leaves and it is doubtful whether they will survive much longer. The northern tree in this plot next to the cultivated trees is distinctly intermediate in character. On the south side it resembles its neighbours under grass; towards the cultivated plot the leaves are larger, darker and there is more growth. The gradual changes brought about by grass in all these cases, including the guava (Plate XVII, fig. 6), suggest that the trees are slowly dying from some form of starvation.

The examination of the root-system of the mature trees under grass in August, 1921, was begun a year later, when the grass effect was becoming marked. At first, the activity of the surface system was compared with that of the cultivated trees. Later, the deep root-systems were explored. Definite results were at once obtained in all the trees. In August, 1922, the plums, peaches, custard-apples, mangoes, litchis and loquats under grass were found to have produced very few active rootlets in the upper foot of soil compared with the controls. In the case of the custard-apple and the loquat, the trees under grass showed a distinct tendency to form new roots below the grass, and for these to grow downwards. In December, 1922, and again in July, 1923, the roots under grass were again examined in several cases down to 8 or 9 feet. Again similar differences were observed, namely, a greatly restricted development of absorbing roots on the surface system compared with the controls. No differences were observed in the dormancy or activity of the deep system.

In these examinations two instances of the striking effect of increased aeration on root-development were observed. In July, 1923, burrowing rats took up their quarters under one of the limes and one of the loquats, in each case on the southern side. Shortly afterwards, the leaves immediately above the rat holes became much darker in colour than the rest. Examination of the soil immediately round the burrows showed a copious development of new active rootlets, far greater even than in the surface soil of the cultivated plot. The extra aeration had a wonderfully stimulating effect on the development of active roots, even under grass. The appearance of the leaves suggested an application of nitrogenous manure.

3. *The effect of aeration trenches on young trees under grass.*

The effect of the aeration trenches in modifying the influence of grass is interesting. No effect was produced on the custard-apple or on the lime, all of which died. The loquats were saved and the trees make a little growth every year. The death of the plums was delayed by the aeration trenches. Two are dead, the third is still shooting from the base. Early in 1921 the roots of this tree were exposed, and later in the year a small colony of rats took up their quarters under the tree and threw out a small mound of earth round the trunk (Fig. 3). The extra aeration so provided has kept this tree alive. The effect of the aeration trenches on the litchi and mango has been considerable and has markedly increased growth. In the guavas the trees provided with aeration trenches are indistinguishable from those under grass.

In March, 1921, measurements of a hundred fully developed leaves were made from the three plots. The results are given in Table I.

At the end of 1920 the roots of one of each species were exposed to a depth of 2 feet in order to ascertain the effect of the extra aeration on the development of

the superficial system. The results were significant. In all cases the superficial roots were much larger and better developed than those under grass, except in the

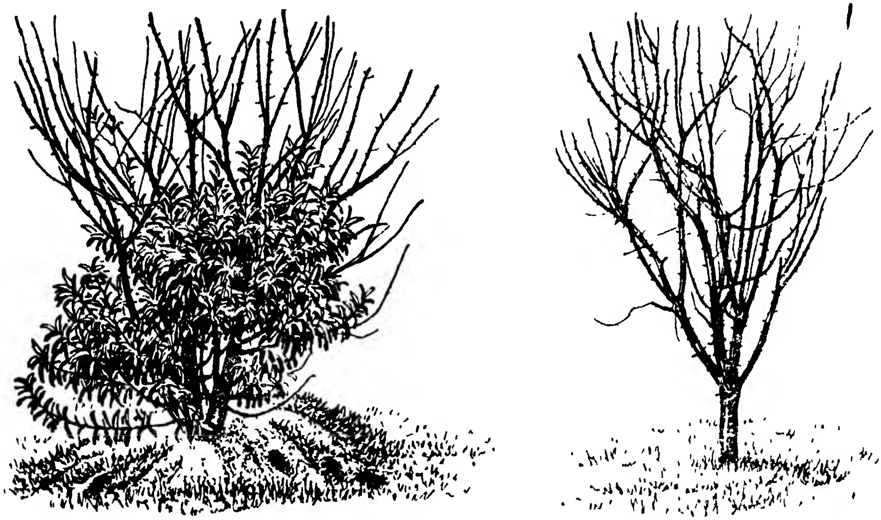

FIG. 3. The effect of burrowing rats on the growth of the plum under grass (June 21, 1923)

TABLE I.

The reduction in leaf size under grass.

	Grass	Grass with aeration trenches	Cultivated
	Cm.	Cm.	Cm.
Plum	3·2×1·1	4·6×1·7	7·1×2·9
Peach	7·1×1·8	8·4×2·3	11·4×3·1
Guava	8·1×3·2	10·6×4·4	11·3×4·4
Mango	11·2×2·9	13·7×3·8	20·9×5·5
Litchi	8·9×2·4	11·5×3·4	12·2×3·5
Lime	3·8×1·6	5·2×2·1	6·4×3·4
Loquat	Trees dead	16·4×4·6	22·1×5·9

guava, where no difference in size could be detected. The roots seemed to be attracted towards the trenches, often branching considerably just before the trench was

reached (Plate XVIII, figs. 2 and 5). Although the trenches exercise a marked attraction for the superficial roots, the trees make use of them in very different ways. The peach, mango, and the loquat make use of the trenches chiefly for the air supply, as there is little or no branching till the trench is reached, when there is a copious development of active roots from the break of the rains till the resting period in the late autumn (Plate XVIII, fig. 3). The lime is the exact opposite of the loquat. There is copious branching in the soil bordering the trenches, but the roots pass through the bricks and then break up again in the soil on the other side of the trench. The lime therefore uses the soil near the trench, but not the trench itself. The rest of the trees -the guava, litchi, and plum- fall between these two extremes and branch freely in the soil round the trench, and also form a certain number of active roots among the broken bricks (Plate XVIII, fig. 6). The aeration trenches are made use of only during the monsoon phase. After the break of the rains new active roots are always found, in or near the trenches first, after which a certain amount of development takes place under the grass.

As would be expected, the trees provided with aeration trenches also develop the deep root-system. This was followed in April, 1921, to 7 feet 9 inches in the case of the plum, to 5 feet 6 inches in the loquat, and 7 feet 6 inches in the lime. In all these cases active roots were met with in the deep soil layers, from about 3 feet 6 inches downwards, exactly as in the cultivated trees.

Even a temporary removal of the grass leads to a profound effect. Whenever the roots of a tree under grass are exposed (for which purpose the grass has to be removed for a few days) there is an immediate increase in growth, accompanied by the formation of larger and darker-coloured leaves. The effect is clearly visible on the foliage above the excavation for as long as two years, but the rest of the tree is not affected.

The general results obtained with clean cultivation, grass, and grass with aeration trenches are shown in Plate XIX, in which representative trees from the various plots have been drawn to scale. The drawings give a good idea of the main results of the experiment, namely: (1) the extremely deleterious effect of grass on young trees; (2) the less harmful effect of the same treatment on mature trees; (3) the partial recovery which results from the aeration trenches, particularly in the case of the loquat, mango, and litchi; (4) the failure of the aeration trenches to save the plums, limes, and custard-apples; and (5) the exceptional nature of the results with the guava, where the trees are able to grow under grass, but with reduced vigour, and where the aeration trenches have had little or no effect.

IV. The cause of the harmful effect of grass.

The distribution of the root-systems of fruit trees and the periodicity of root activity, under cultivation and under grass, have so far been considered. Without

exception the eight species examined possess two very distinct root-systems which fulfil separate functions. The deep system comes into action during the dry season and enables the trees to absorb water and minerals from the soil layers just above the water-table. By this means growth is possible at a time when the moisture in the surface soil is too low for root-development. The deep roots also help to anchor the trees. The larger and more developed of the two systems is superficial. This occurs in the upper 18 inches of soil and becomes active at the break of the rains, remaining effective till the beginning of the hot weather in the following March, after which it is dormant. The manner in which the roots of the trees and the soil come into gear, as it were, throughout the year is of great interest. This efficient gearing not only enables the trees to make the best of the growth factors, but also renders them independent of the distribution of the rainfall, and of any apparent deficiency (as measured by the standards of the Occident) in the chemical composition of the surface soil. The trees utilize, not the upper 9 inches, but nearly 20 feet of finely-divided alluvium.* The only period during which the depth of soil made use of by the roots is relatively small is in August and September, when the sub-soil water rises and permeability falls off, due to the temporary formation of soil colloids. During this brief period only does the depth of soil used by the trees approximate to European standards. It is a period of comparative rest.

Besides the facts of distribution and periodicity, three other striking results emerge from the exploration of the root-systems of these trees. These are as follows :-

(1) The grass affects the superficial system only, and has little or no effect on the deep roots. Only in the guava, which is the least susceptible to grass, is anything like a normal superficial system developed. The general effect of the grass is to check the growth of the surface roots and to reduce greatly the number of active rootlets.

(2) The various root-systems, at all seasons and under all conditions, exhibit a remarkable reaction to improved aeration. Even during the dry season, when the permeability of the soil is at its best, the deep roots always branch freely and form abundant active rootlets in the various cavities and tunnels which occur, and also in the deep soil layers (like fine sand) where the texture is open. During the early rains the trees make great use of the artificial aeration trenches, branching freely and producing large numbers of active rootlets in the soil round the trench or among the brick fragments or in both. During the second half of the monsoon, when the permeability of the soil falls off, the roots in the surface soil become markedly aerotropic and grow towards the surface, and even beyond it into the air. At lower depths, the active roots die. Among the trees under grass, the aerotropism of the surface roots of the guava only is sufficiently strongly developed for the rootlets to grow

* The nitrates produced in the surface soil must be carried down to nearly 20 feet, otherwise the trees could not obtain a supply of this essential food material during the hot season.

through the grass roots and to reach the surface. This species does best under grass. Another interesting reaction to improved soil aeration during the rains was shown by the plums, limes and loquats under grass, when burrowing rats established themselves under the trees. The soil immediately round the tunnels was quickly filled with absorbing roots. After the rains, when the sub-soil water falls and soil aeration is resumed, there is a progressive downward development of root activity, until, at the beginning of the hot weather, the whole of the deep system is again effective.

(3) As soon as the surface system becomes active in the early rains there is a marked increase in the growth of the leaves and shoots. This period is a time of active nitrification. Immediately the surface root-system comes into effective contact with soil rich in combined nitrogen, the leaves increase in size, become dark green and the internodes lengthen. A similar, but far less pronounced, increase in the size of the leaves and in the tone of colour takes place in the trees under grass.

The evidence afforded by the trees themselves suggests, therefore, that the grass is harmful in two ways—by restricting the aeration of the surface roots in the monsoon, and by reducing the supply of combined nitrogen during the whole year. Both these matters have been investigated in detail, and the results are dealt with below. Two other factors—soil temperature and soil moisture which might possibly operate have also been examined. The results were negative in each case, and it will be convenient briefly to refer to them at this point before dealing with the effect of grass on soil aeration and on the nitrogen supply.

As the activity of the surface roots of the trees, the growth of grass, and the monsoon, all occur together, and as the rainfall is far in excess of the requirements of both grass and trees, the supply of water is not likely to affect the problem. After the rains, when the ground-water falls, the surface soil under grass, except in occasional dry years, always contains sufficient moisture for growth during October and November, after which both grass and trees begin their resting period. In the hot weather, when the surface roots are dormant and the trees obtain water from the deep soil layers, there is always ample moisture at these depths, both under grass and under clean cultivation. Circumstances, therefore, eliminate soil moisture as an important factor in the problem.

A continuous daily record of the early morning (8 A.M.) and late afternoon (sunset) soil temperatures, at 6 and 12 inches from the surface, has been maintained from April 20, 1921, to the end of 1923. Readings were taken under grass and also under cultivated soil kept free from weeds. At 12 inches the minimum temperature under grass (in a resting condition) during the hot weather period was practically the same as that under cultivated soil. In the rains, however, the temperature under grass (then in active growth) was about 2° F. above that under the cultivated plot. The results clearly indicate that the effect of the grass on the temperature of the surface soil is negligible.

The advantage to the trees of the increased aeration provided by the trenches suggested the periodical examination of the soil gases. Determinations of the amount of carbon dioxide in the soil air at a depth of from 9 to 12 inches were carried out during 1919 under grass, under grass with aeration trenches, and under cultivated soil. About 10 litres of air were drawn out of the soil at each determination and passed through standard baryta, which was afterwards titrated in the ordinary way. The 1919 results are given in Table II and are set out graphically in Fig. 4. Those of 1920 and 1921 confirm these figures in all respects.

The grass increases the amount of carbon dioxide in the soil air throughout the year, and particularly during the rains at a time when the superficial root-system is most active. The trenches, as would be expected, improve the aeration. Do the roots suffer from the excess of carbon dioxide, or from too little oxygen? As rainfall is a saturated solution of oxygen,[1] and as nearly 50 inches on the average are received during the four months (June 15—October 15), during which the percentage of carbon dioxide in the surface soil is highest, the harmful factor is more likely to be the presence of carbon dioxide than a slightly diminished oxygen supply. This agrees with the view taken by Clements [2] in a recent review of the literature of the subject. The figures in Table II show that during the monsoon the volume of carbon dioxide in the pore spaces under grass is increased about five-fold in

TABLE II.

*Percentage by volume of carbon dioxide in the soil gas, under grass and clean cultivation, Pusa, 1919.**

Date and month when soil gas was aspirated and analysed	Plot No. 1 Grassed	Plot No. 2 Grassed but partially aerated by trenches	Plot No. 3 Surface cultivated	Rainfall in inches since January 1, 1919
January 13, 14 and 17	0·444	0·312	0·269	nil
February 20 and 21	0·472	0·320	0·253	1·30
March 21 and 22	0·427	0·223	0·197	1·33
April 23 and 24	0·454	0·262	0·203	2·69
May 16 and 17	0·271	0·257	0·133	3·26
June 17 and 18	0·341	0·274	0·249	4·53
July 17 and 18	1·540	1·090	0·304	14·61
August 25 and 26	1·590	0·836	0·401	23·29
September 19 and 20	1·908	0·931	0·450	30·67
October 21 and 22	1·297	0·602	0·365	32·90
November 14 and 15	0·853	0·456	0·261	32·90
December 22 and 23	0·398	0·327	0·219	32·92

[1] Richards, E. H. *Jour. of Agri. Sc.*, Vol. VIII, p. 331 (1917).

[2] Clements, F. E. Aeration and Air Content: The Role of Oxygen in Root Activity. *Publication No. 315, Carnegie Institution of Washington*, 1921.

* The determinations were carried out by Mr. Jatindra Nath Mukherjee, B.Sc., of the Chemical Section, Pusa.

comparison with the soil air of cultivated land. This difference is considerable. Owing, however, to the far greater solubility of carbon dioxide in water than oxygen,

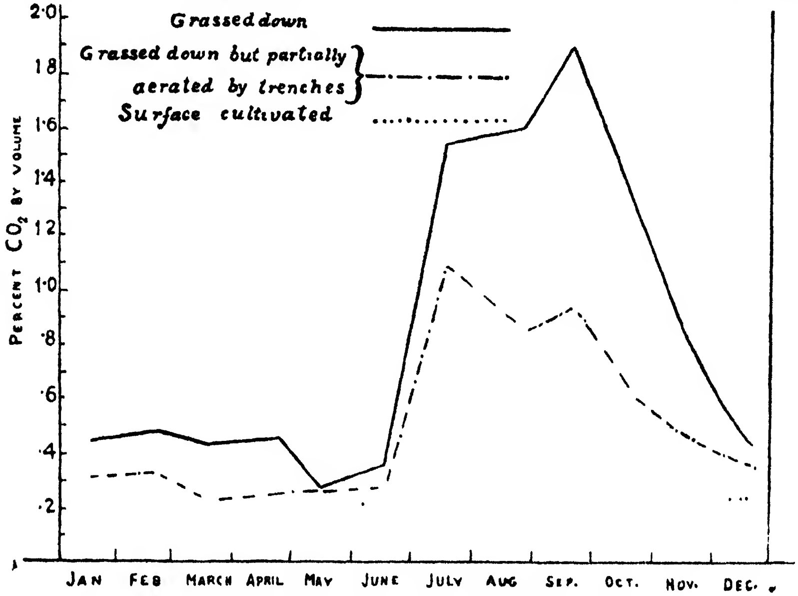

FIG. 4. Carbon dioxide in soil atmosphere, Pusa, 1919.

and the circumstance (suggested by Russell and Appleyard [1]) that the relative amounts of carbon dioxide and oxygen actually dissolved in the moisture films surrounding the pore spaces are far more significant from the point of view of an absorbing root than the composition of the general soil atmosphere, it is probable that the root hairs are actually subjected to a very much higher percentage of carbon dioxide than the figures in Table II suggest.

The production of large quantities of carbon dioxide during the rains does not seem to be sufficient to explain the whole of the harmful effect of grass. That this is only one factor in the problem is suggested by the restricted growth of the guava under grass, in spite of the fact that the roots are able not only to obtain abundant oxygen but also to escape the direct influence of the carbon dioxide. In spite of the copious aeration provided by the roots, the guava under grass only attains about half the height under clean cultivation. Moreover, the aeration trenches have only modified the harmful effect of grass in the other trees. They have not removed it.

Besides producing carbon dioxide in injurious amounts, the presence of grass is bound to influence the supply of food materials. The starved appearance of the

[1] Russell, E. J., and Appleyard, A. *Jour. of Agri. Sc.*, Vol. VII, p. 1 (1915).

trees under grass, the reduction in size, and the yellow colour of the leaves, suggest that combined nitrogen is in serious defect. This agrees with the general agricultural experience in Bihar. When land under grass in this tract is brought into cultivation, it is at first practically infertile, and only produces a normal crop if heavily manured with some nitrogenous manure. That the grass carpet does reduce very considerably the amount of nitric nitrogen has been proved by direct determinations. These were carried out at Pusa by Mr. Jatindra Nath Mukherjee,[1] who found that at all periods of the year, except at the break of the rains, the amount of nitric nitrogen in the upper 18 inches of soil under grass, varies from 10 to 20 per cent. of that met with in the cultivated plots.

An interesting confirmation of the harmful effect of grass in diminishing the available nitrogen has frequently been observed in the experimental plots in the Botanical Area at Pusa. To provide efficient drainage a number of trenches with sloping sides and grass borders have been arranged.[2] The grass borders are about 2 feet wide and adjoin the land under cultivation. Crops like cereals, oilseeds and tobacco, which require a large amount of nitrogen, always show a pronounced edge effect. The plants next the grass border are stunted with small yellow leaves. The effect first diminishes and then disappears altogether, at about 3 feet from the grass. Leguminous crops, on the contrary, never show this yellowing of the foliage, neither is their growth restricted to the same extent. That the reduction in size and the yellow colour of the cereals is largely due to want of nitrogen has often been proved by manuring the edges of the plots with nitrate of soda or sulphate of ammonia, when the yellowing disappears and the diminution in growth becomes considerably less. Cereals then behave like leguminous crops.

One result of grassing over fruit trees must therefore be a serious reduction in the nitrogen supply. This aspect of the subject has been investigated at Cornell, in the case of the apple, by Lyon, Heinicke and Wilson.[3] These investigators have carefully tested the suggestion of Lyon and Bizzell[4] that lack of sufficient available nitrogen, due to the property that grass possesses of causing an almost complete disappearance of nitrates in the soil, might account for the injury to apple trees brought about by the continuous growth of grass. Applications of 900 lb. of nitrate of soda to the acre to apples under grass increased the growth to about two-thirds that on cultivated plots which received no nitrate. That some other factor besides a supply of nitrogen is brought into operation by clean cultivation was recognized by Lyon and his collaborators, who stated (p. 11): "This treatment (*i.e.*, cultivation) brought about some condition other than the production of nitrates that benefited the growth." From the results obtained at Pusa and described in

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[1] *Agri. Jour. of India.*, Vol. XIX, p. 151 (1924).

[2] Howard, A. Soil Erosion and Surface Drainage. *Bull. 53, Agri. Res. Inst. Pusa*, 1915.

[3] Lyon, T. L., Heinicke, A. J., and Wilson, B. D. The Relation of Soil Moisture and Nitrates to the Effects of Sod on Apple Trees. *Memoir 63, Cornell Univ. Agri. Expt. Station*, 1923.

[4] Lyon, T. L., and Bizzell, J. A. Some Relations of Certain Higher Plants to the Formation of Nitrate in Soils. *Memoir 1, Cornell Univ. Agri. Expt. Station*, 1913.

this paper there is every probability that the condition referred to is the proper aeration of the soil which is injuriously affected by grass, with the production of carbon dioxide in harmful amounts.

The presence of a soil toxin produced by the grass would, however, also explain the results. Some crucial experiment is therefore required to determine whether the harmful effect of the grass, which remains after the defect in the nitrogen supply is made good, is due to carbon dioxide or to a soil toxin. Fortunately, the guava, the roots of which aerate themselves in the rains, is exactly what is required to decide between these two views. If the harmful factor is carbon dioxide, the addition of combined nitrogen to the guava under grass will eliminate the effect of grass altogether. If a soil toxin is involved, the harmful effect will remain. The matter was put to the test of experiment during the rains of 1923. Sulphate of ammonia at the rate of 10 cwt. to the acre was applied to the western halves of two of the guava trees under grass. The response was immediate. In both cases the leaves increased in size, the internodes lengthened and the colour of the foliage deepened in tone on the manured halves of each tree. Compared with the trees under cultivation, the growth under grass, as well as the amount of flowering and fruiting after the addition of sulphate of ammonia, was even greater than under clean cultivation. This is shown by the average size of 50 leaves of the experimental trees after the season's growth of 1923 was completed—

	Cm.
Manured half of tree (grassed over in 1916)	$10{\cdot}9 \times 4{\cdot}5$
Manured half of tree (grassed over in 1921)	$11{\cdot}7 \times 4{\cdot}9$
Unmanured half of same tree (grassed over in 1921)	$8{\cdot}3 \times 3{\cdot}3$
Cultivated plot (control)	$10{\cdot}5 \times 4{\cdot}0$

These results are so definite that they leave no doubt that manuring the guava under grass with the proper amount of sulphate of ammonia will entirely remove the harmful effect of the grass. The fact that the addition of nitrogen in these cases led to *more growth* than under cultivation shows that no additional adverse factor, such as a soil toxin, is involved. In the guava the harmful effect of grass is, therefore, confined to interference with the supply of combined nitrogen. Once this is removed, the presence of the grass makes no difference.

In the case of the litchi and loquat, the roots of which are unable to aerate themselves in the rains, the results agree with those obtained with apples at Cornell. A distinctly harmful effect remains after nitrate of soda, at the rate of 900 lb. to the acre, has been added to the trees under grass. These then occupy an intermediate position—as regards extent and colour of foliage, times of flowering, and production of new leaves—between the trees under grass without nitrogen and those under cultivation without nitrogen. The effect of a grass covering at Pusa is, therefore, very similar to that at Cornell. At both places, grass leads to the disappearance of nitrates in the soil and restricts root-development. The effect is only partially removed by the addition of nitrate of soda.

The harmful effect of grass on fruit trees, which has been observed on certain soils in Great Britain, the United States and India, seems to be due to two causes, both of which are related to the aeration of the soil. The first appears to be a direct effect, due to the accumulation of large quantities of carbon dioxide in the soil air. In close soils, like those at Woburn and Pusa, this gas is retained long enough to check root-development. The second cause is a greatly diminished supply of combined nitrogen, which is one of the consequences of the long-continued growth of grass. Whether the grass reduces the amount of nitrification, besides absorbing some of the nitrate after it is formed, is a matter which requires further investigation. Much work on the chemistry and on the flora of the soil under grass is needed before the relations between grass and nitrification are completely understood.

V. Forest trees and grass.

The relations between grass and a number of common Indian forest trees have been under observation at Pusa for the last three years, and an attempt has been made to ascertain the nature of the weapons by which these trees are not only able to thrive under grass, but also to vanquish it, if allowed free competition. All the individual trees studied have been under grass for at least 18 years, since the foundation of the Pusa Research Institute, some of the older ones possibly for still longer periods. They all thrive remarkably well and show none of the harmful effects exhibited by fruit trees. It is impossible to say how much the trees are restricted in their growth by grass, as no control plots under clean cultivation are available in these cases. The trees investigated were the following :—

Table III.

Forest trees under grass in the Botanical Area, Pusa.

Species	Time of flowering	Time of leaf fall
Polyalthia longifolia, Benth. and Hook., f.	February to April	April
Melia Azadirachta, L.	March to May	March
Ficus bengalensis, L.	April-May	March
Ficus religiosa, L.	April-May	December
Ficus infectoria, Roxb.	February-May	December-January
Millingtonia hortensis, Linn., f.	November-December	March
Butea frondosa, Roxb.	March	February
Phyllanthus Emblica, L.	March-May	February
Tamarindus indica, L.	April-June	March-April
Tectonia grandis, Linn., f.	July and August	February-March
Thespesia populnea, Corr.	Throughout the year, but chiefly in the cold season.	April
Pterospermum acerifolium, Willd.	March-June	January-February
Wrightia tomentosa, Roem. and Schult	April-May	January-February
Lagerstrœmia Flos-Regina, Retz	May	December-January
Dalbergia Sissoo, Roxb.	March	December-January

Whilst most of the forest trees at Pusa flower and come into new leaf in the hot weather and then proceed to form new shoots, nevertheless a distinct change is visible in the colour and appearance of the foliage after the early rains. The leaves then become darker and more glossy, as if they had received large dressings of nitrogenous manure. In August, 1922 and 1923, the superficial root-systems (under grass) of these fifteen species were examined. The results were remarkably uniform. Without exception, all the trees produced abundant, active, normally developed rootlets in the upper two or three inches of soil and also on the surface. They therefore compete successfully with grass, both for minerals and for oxygen. The large superficial roots were also well developed and compared favourably with the corresponding root-system of fruit trees under clean cultivation. The grass covering had apparently no harmful effect on the root-system near the surface.

As most of the trees examined flower and change their leaves either immediately before or during the hot weather, it seemed probable that they would possess a deep root-system for use in the dry season, very like that of the fruit trees. The root-system of *Dalbergia Sissoo* was explored down to 14 feet 10 inches in April, 1921. Two kinds of roots occurred—a well developed surface system which was then dormant and a deep system which grew vertically down towards the level of permanent water. Fresh active roots were abundant in the deep soil layers, particularly from 10 feet 2 inches to 14 feet 9 inches. The best development was met with in a layer of fine sand between 12 feet 7 inches and 14 feet 10 inches.

During the rains of 1923, the root-systems of the rest of the trees were explored. The first fourteen species in Table III were examined during the month of August. The rainfall in 1923 was exceedingly short, and the level of permanent water during this month remained in the neighbourhood of 17 feet. In all cases the general results were similar. The trees all possessed two kinds of roots, exactly as in the case of *Dalbergia Sissoo* and of the fruit trees in cultivated soil. The superficial system was well developed, and from this numerous active roots were being produced in the surface soil and in the surface film. From the upper roots thin, whip-like branches were given off in large numbers, which grew vertically downwards towards the water-table. At first these did not branch at all, then the roots divided several times and finally broke up in the deep sand layers at about 13 feet into numerous fine branches. In the case of *Phyllanthus Emblica*, L., the roots were followed to 19 feet—2 feet below the water level. The fine roots in the water were just alive, but were not growing. Just above this, between 15 feet and 16 feet in sand, new active roots were found. This exposure is interesting in showing that the rise of the sub-soil water puts out of action the roots which supply the trees in the hot weather. Two exceptions were met with in these exposures, namely, *Millingtonia hortensis* and *Melia Azadirachta*. In the former, the root-system did not extend below 11 feet 6 inches from the surface, where it ended in a mixture of clay and sand. Between 9 and 11 feet, no less than nine cases of the destruction of the deep roots were observed in one exposure. These had, in all probability, been killed by the rise of

sub-soil water in 1922. In August, 1923, the tree was busily repairing the damage by sending downwards new roots just above the points of decay. This was perhaps the best example met with in this investigation of the periodical repair of the damage done to the deep root-system by a long-continued rise of the sub soil water. That the roots of *M. hortensis* normally utilize the deep sand layers was suggested by following the dead roots to 17 feet in sand. The deep root-system of *Melia Azadirachta* was quite different from the rest. Although the deep roots penetrated to 13 feet in sand, they did not grow straight downwards in the ordinary way. These roots, which had numerous well-developed lenticels, had a marked tendency to run horizontally at all depths and to make use of the burrows left by insects. After running horizontally for a time, the roots then grow downwards to the deep sand layer, giving off horizontal branches on the way. Besides *Millingtonia hortensis*, examples of repair of the deep system were noted in the following cases: *Ficus bengalensis* (two cases in sand at 15 to 16 feet), *Ficus religiosa* (two cases in sand between 18 and 19 feet), *Tectonia grandis* (one case between 9 and 10 feet, two cases between 12 and 13 feet), *Butea frondosa* (one case at 10 feet in blue clay, another at 17 feet in sand).

The extent of the deep root-system in all these trees fully explains their independence of drought in the hot weather and the formation of flowers, leaves and new shoots during the hot dry months of April, May and June. The trees are able to make full use of the water and minerals in the deep layers of moist sand just above the water-table. The hot-weather foliage is always a paler green than that of the monsoon, thereby indicating that combined nitrogen is in defect in the deep layers in the dry season, as would be expected.

The facts connected with root distribution and root periodicity in forest trees explain why these trees do so well under grass and are able to vanquish it if allowed free competition. The chief weapons which enable forest trees to oust grasses and herbs from the habitat are the following:—

(1) The deep root-system admits of growth during the dry season when the grass is dormant and enables the trees to utilize moisture and food materials in the soil down to at least 20 feet. This markedly extends the period of assimilation.

(2) The habit of the trees is a great advantage in the struggle for light.

(3) The active roots of the surface system are resistant to poor soil aeration and are able to reach the surface and to compete successfully with the grass for oxygen and for minerals.

The character which distinguishes forest trees from fruit trees appears therefore to be the power possessed by the surface roots of the former to resist the harmful effects of an atmosphere rich in carbon dioxide. That the roots of different species vary greatly in this respect is well known.[1] So great is this resistance in the case of forest trees that the roots are able to reach the surface in the presence of a grass carpet

[1] Clements, F. E. *loc. cit.*

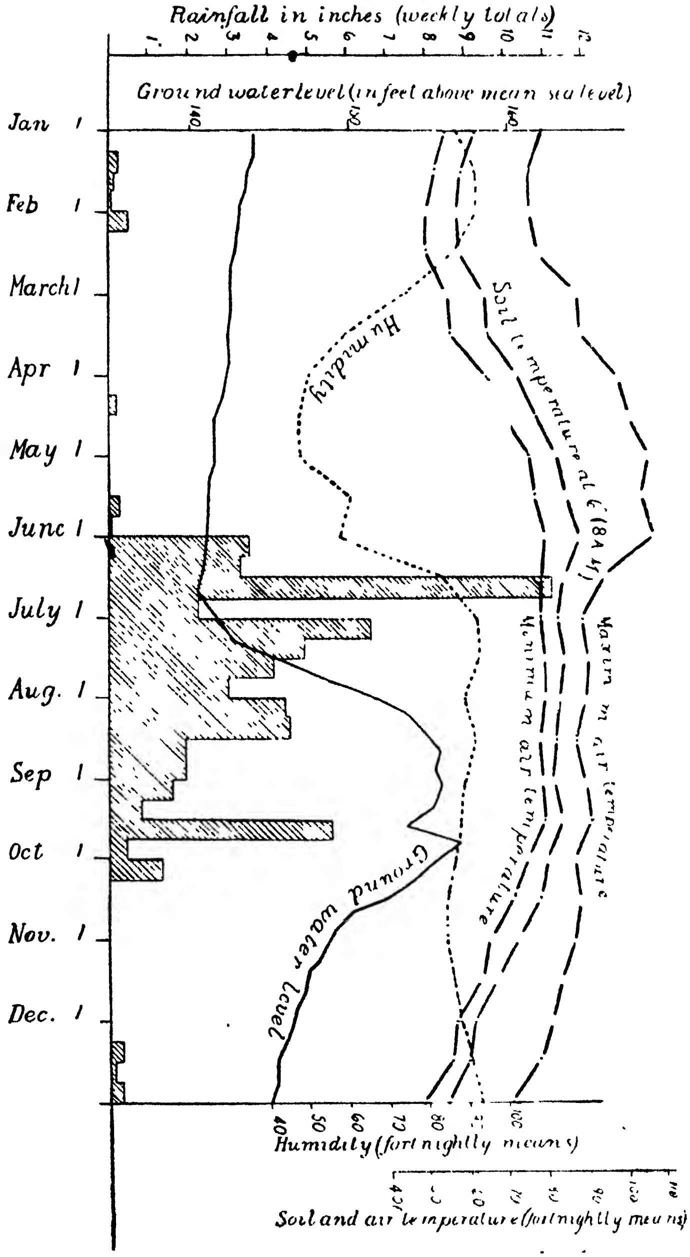
in active growth, and to obtain oxygen as well as a portion of the combined nitrogen available. The surface roots of fruit trees, on the contrary, appear to be very susceptible to carbon dioxide and try to avoid it by growing downwards. The surface roots are therefore deprived both of oxygen and of combined nitrogen during the rains and the trees slowly starve. The guava is an exception among fruit trees. Here the active roots reach the surface in the rains and the trees are able to maintain themselves. This explains why the pastures of Grenada and St. Vincent in the West Indies are so rapidly invaded and destroyed by the wild guava.

An exact knowledge of the facts relating to the distribution of the root-system and of the zones of root absorption during the life of the plant is clearly necessary for a scientific understanding of crop-production. Such knowledge is essential before the manner in which the soil and the crop are geared together can be appreciated. Once this is known, many problems connected with the choice of varieties for the various soil types, with methods of cultivation, manuring and irrigation, pass from the region of empiricism into one more approaching that of scientific experiment. Further, this knowledge is likely to throw light on resistance and susceptibility to disease. It is remarkable that in permanent plantations, such as tea, coffee, cocoa, rubber, fruit and hops, in which the capital invested is very large, practically no detailed information of the distribution of root activity during the year is available. As regards the broad facts of root distribution, a beginning has been made at various centres in the United States,[1] Great Britain[2] and India[3]. The detailed investigation of the life-history of the root-systems of individual plants remains, however, almost untouched, while the task of unravelling the root relations of the vegetable kingdom as a whole to each other and to the various soil types, which has been started in the United States by the Carnegie Institution of Washington, is stupendous. Nevertheless, it is clearly essential in the ecological studies of the future.

[1] Weaver, J. E., Jean, F. C., and Crist, J. W. Development and Activities of Crop Plants. *Publication No. 316, Carnegie Institution of Washington*, 1922.

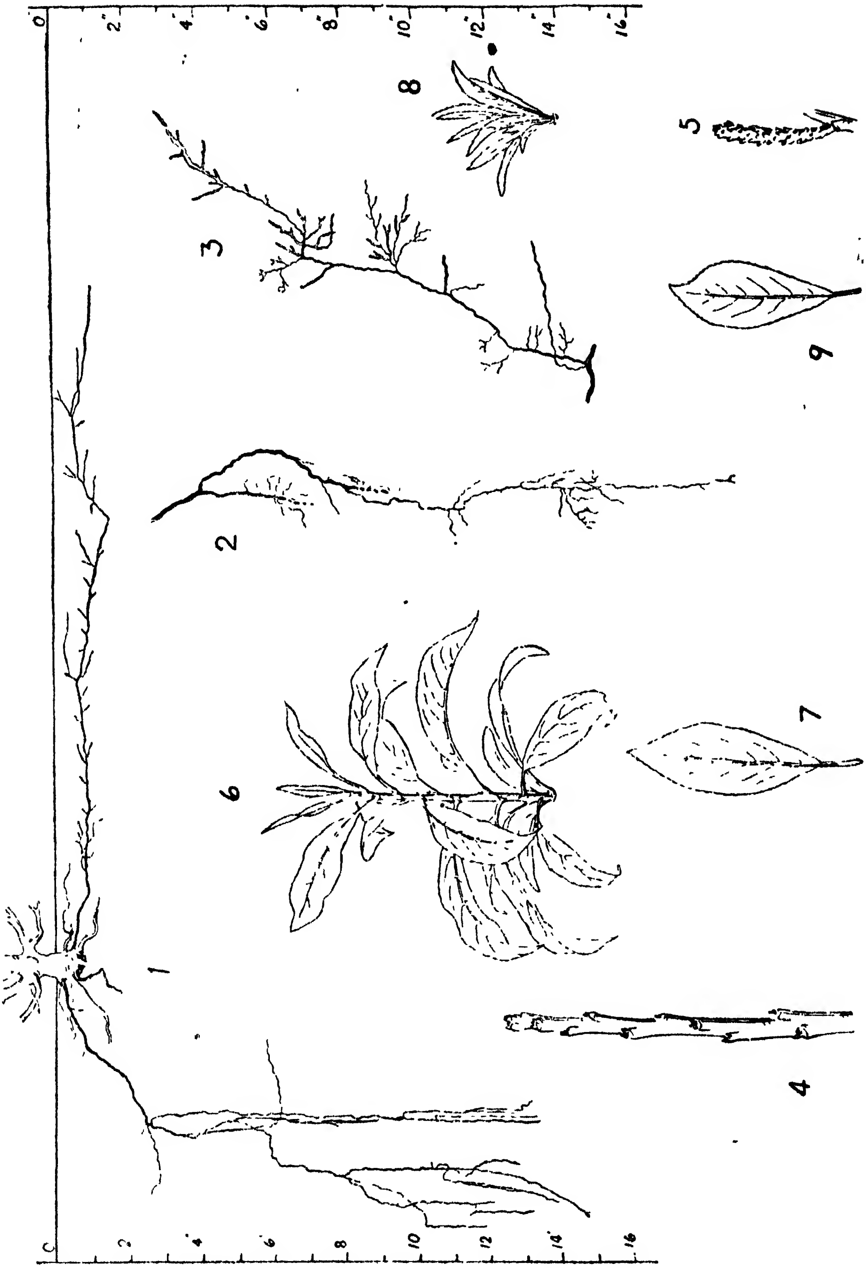
[2] Barker, B. T. P. *Annual Reports of the National Fruit and Cider Institute, Long Ashton, Bristol*, 1914, 1920 and 1921.—Hatton, R. G. *Jour. Roy. Hort. Soc.*, Vol. XLII, p. 361 (1916-17), and Vol. XLV, pp. 257 and 269 (1919-20).—Peren, G. S. *Jour. of Pomology & Hort Sc.*, Vol. III, p. 96 (1923).

[3] Howard, A., and Howard, G. L. C. The Economic Significance of the Root-Development of Agricultural Crops. *Agri. Jour. of India*, Indian Science Congress Number (1917).

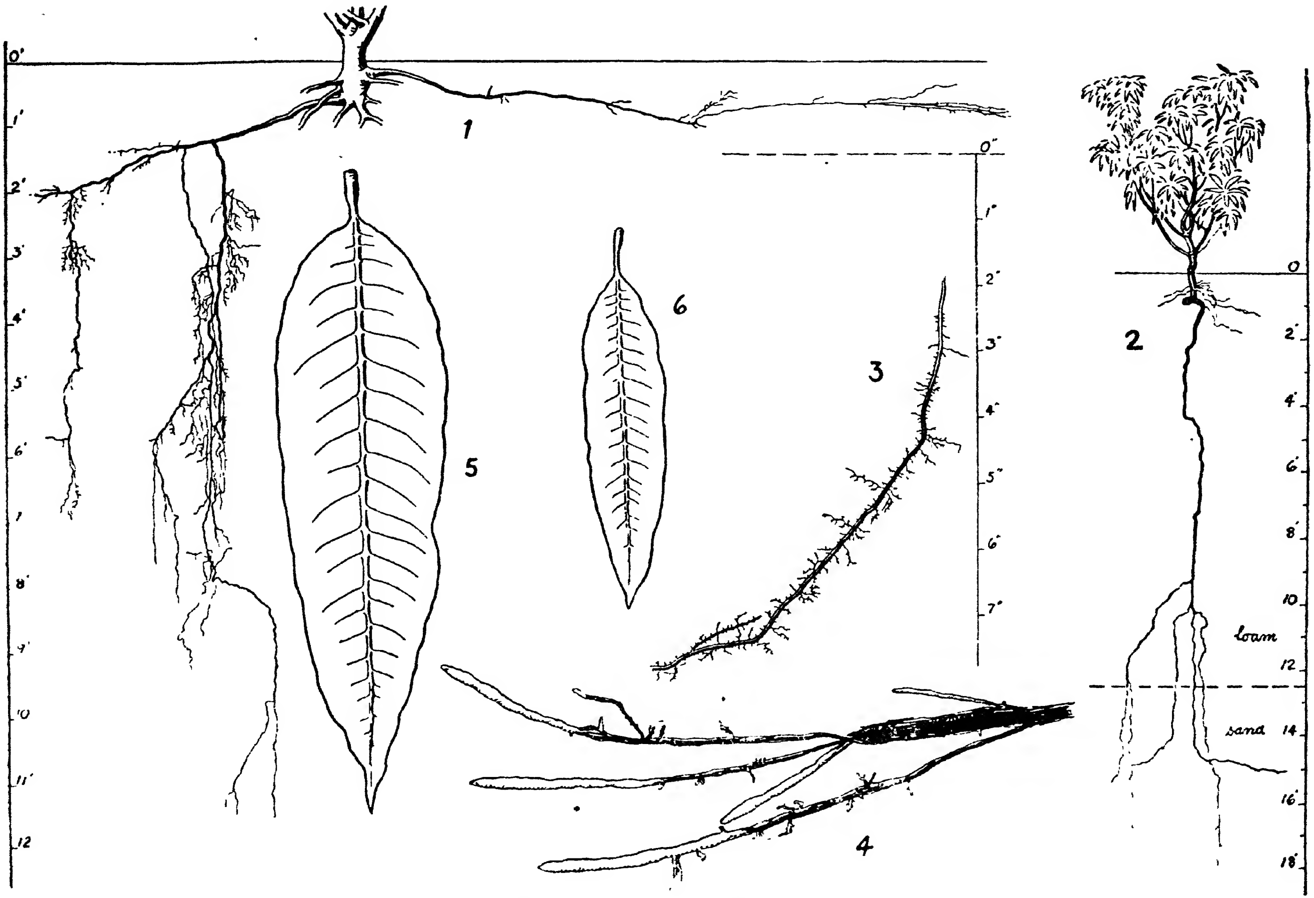


RAINFALL, TEMPERATURE, HUMIDITY AND DRAINAGE, PUSA, 1922.

PLATE XV.

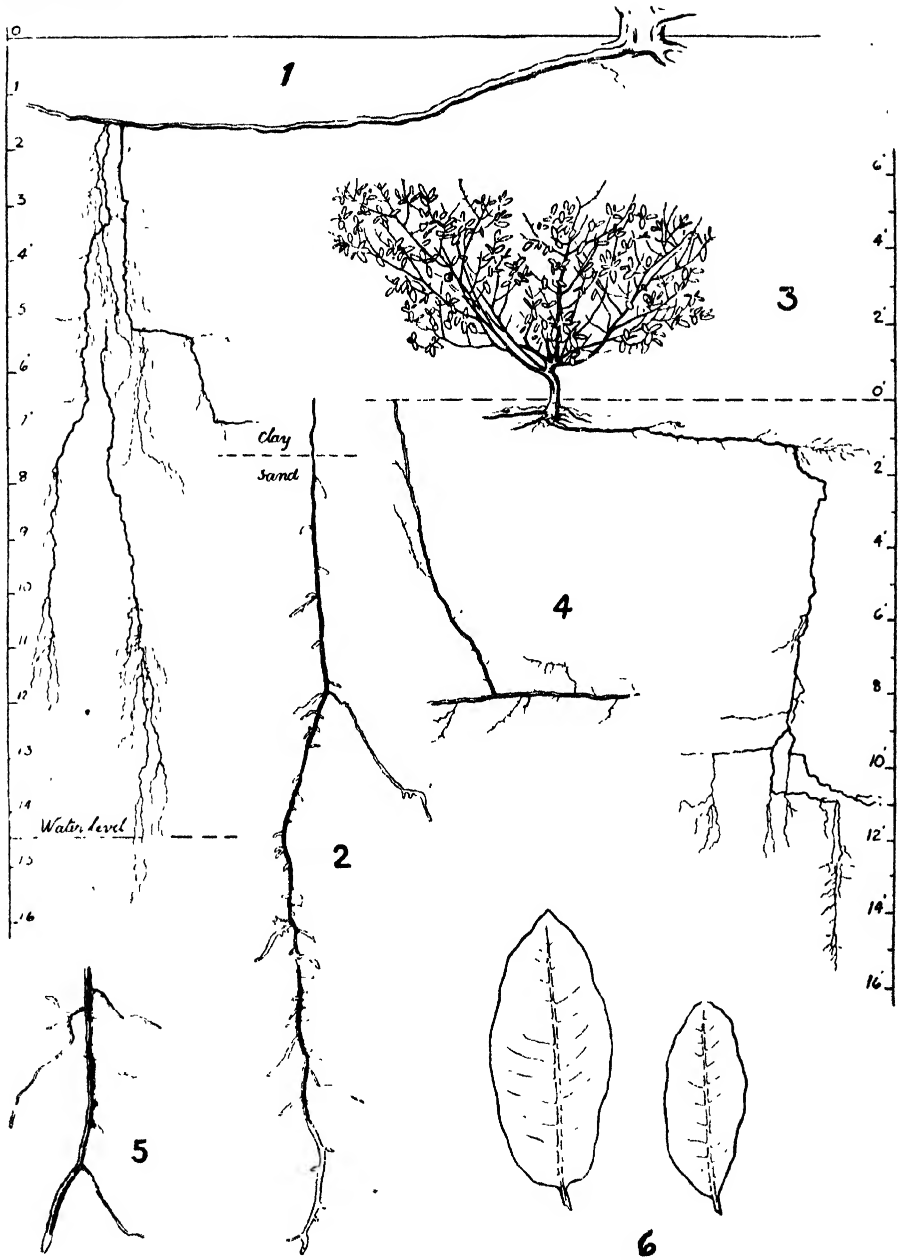


PLUM (PRUNUS COMMUNIS HUDS.).

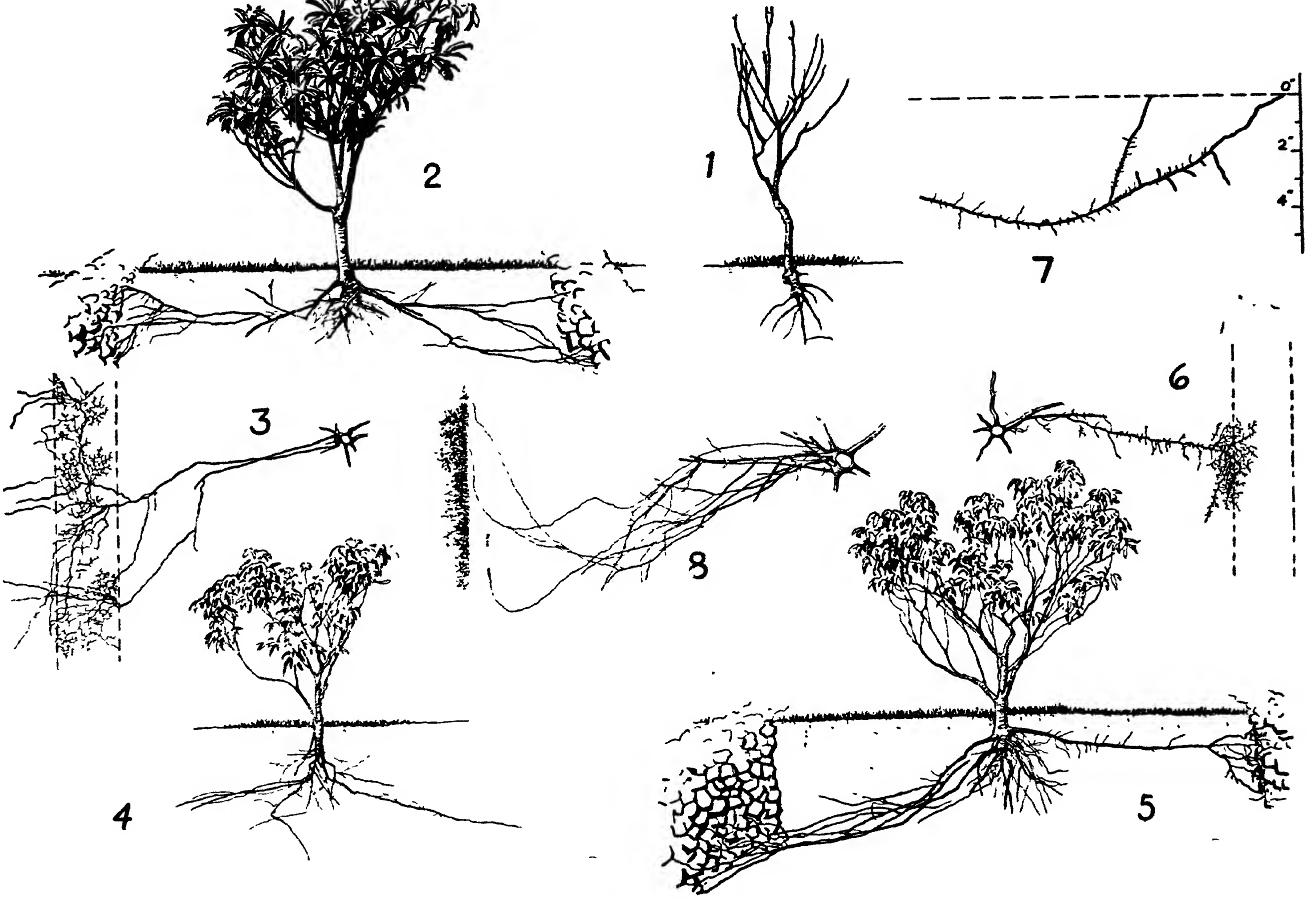


MANGO (MANGIFERA INDICA, L.)

PLATE XVII₂

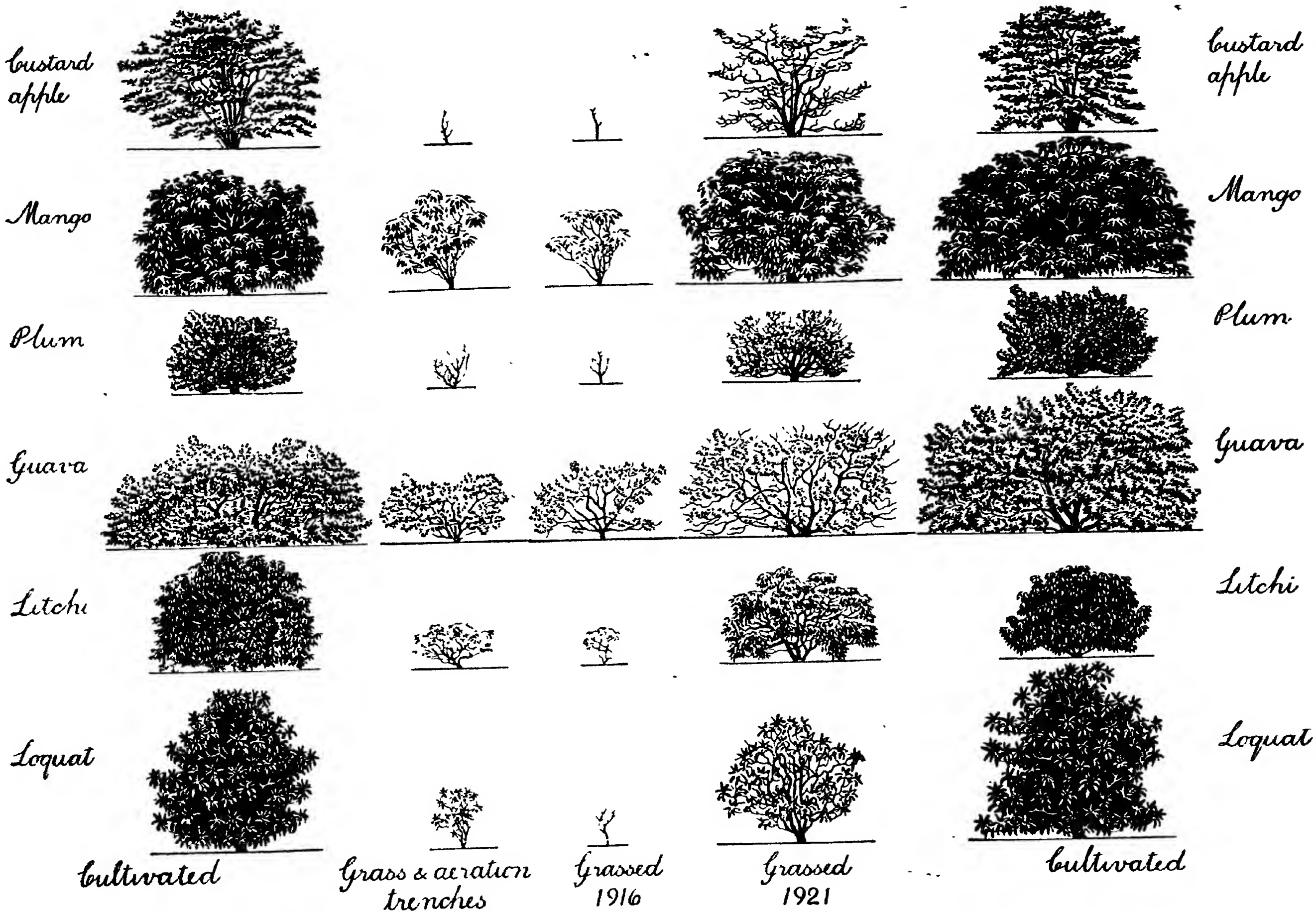


GUAVA (PSIDIUM GUYAVA L.).



THE REACTION OF THE ROOT-SYSTEM UNDER GRASS TO IMPROVED AERATION.

PLATE XIX.



THE HARMFUL EFFECT OF GRASS ON FRUIT TREES, PUSA, 1923.

DESCRIPTION OF PLATES.

PLATE XIV. RAINFALL, TEMPERATURE, HUMIDITY AND DRAINAGE, PUSA, 1922.

PLATE XV. PLUM (*Prunus communis*, Huds.).

FIG. 1. Superficial and deep roots (April 25, 1921).

FIG. 2. The repair of the deep root-system (August 6, 1923).

FIG. 3. Superficial rootlets growing towards the surface (August 12, 1922).

FIGS. 4 & 5. New wood under cultivation and grass (January 25, 1923).

FIGS. 6 & 7. New shoots and leaves under clean cultivation (April 5, 1923).

FIGS. 8 & 9. The corresponding growth under grass (April 5, 1923).

PLATE XVI. MANGO (*Mangifera indica*, L.).

FIG. 1. Superficial and deep roots (October 29, 1921).

FIG. 2. Deep root-system under grass (April, 1921).

FIG. 3. Superficial rootlet showing aerotropism (August 9, 1921).

FIG. 4. Formation of new roots (26 inches to 44 inches below the surface), following the fall of the ground-water (October 28, 1921).

FIGS. 5 & 6. Leaves under cultivation and grass (May 21, 1921).

PLATE XVII. GUAVA (*Psidium Guyava*, L.)

FIG. 1. Superficial and deep roots (November 23, 1921).

FIG. 2. The influence of soil texture on the formation of rootlets (March 29, 1921).

FIG. 3. The root-system under grass (April 21, 1921).

FIG. 4. Superficial rootlet growing to the surface (August 28, 1921).

FIG. 5. Formation of new rootlets in fine sand following the fall of the ground-water (November 20, 1921).

FIG. 6. Reduction in the size of leaves after 20 months under grass (right).

PLATE XVIII. THE REACTION OF THE ROOT-SYSTEM UNDER GRASS TO IMPROVED AERATION.

FIGS. 1 & 2. Root-development of the loquat under grass (right) and under grass with aeration trenches (left).

FIG. 3. Utilization of the aeration trench by the loquat during the monsoon (July 24, 1921).

FIGS. 4 & 5. Root-development of the litchi under grass (left) and under grass with aeration trenches (right).

FIG. 6. Utilization of the soil adjoining the aeration trench by the litchi (August 28, 1921).

FIG. 7. Aerotropic rootlets of the litchi (August 7, 1921).

FIG. 8. Superficial roots of the custard-apple under clean cultivation turning away from the grass border.

PLATE XIX. THE HARMFUL EFFECT OF GRASS ON FRUIT TREES, PUSA, 1923.

NOTES

SPINNING TESTS OF INDIAN COTTONS.

The following tests on (bale) samples of Indian cottons sent by the Indian Cotton Committee have been carried out with the co-operation of the Oldham Master Cotton Spinners' Association.

Samples of the raw cotton, and of the product after it has passed through the various processes, can be seen at the offices of the British Cotton Growing Association, 333-350, Royal Exchange, Manchester.

Standards are given in italics.

February, 1925.

Firm making test	Growth	Bale No.	Per cent. loss up to card sliver, including invisible loss	Nominal counts	Actual counts at spindle point	Lea strength test in lb.	Actual turns per inch	Estimated value compared with price of current month futures (universal standard)
No. 1	*American*		*8·5*	*Weft 30*	*31·18*	*39*	*21*	*50 pts. on*
				,, 28	*29·00*	*45·06*	*19 87*	
				Twist 34	*31 27*	*41*	*30·4*	
	1027 ALF (Surat)	6	10·87	Weft 28	30·20	46·125	19·75	30 pts. on
				Twist 34	37·30	37·6	30·4	
	Dharwar No. 1	5	11·25	Weft 30	30 96	47·625	21	45 pts. on
				Twist 34	35·83	43·75	30·4	
	Cambodia	2	10·75	Weft 28	29 82	48	20	40 pts. on
				Twist 34	36·89	41	30·4	
No. 2	*Texas American*		*7·12*	*Twist 30*	*33·03*	*48·87*	*20·9*	*75 pts. on*
				,, 36	*36·62*	*42·62*	*22·5*	
				Weft 24	*25·75*	*51 75*	*15·78*	
				,, 28	*28·18*	*55·75*	*17·18*	
	285 F (Punjab-Am.)	21	14·36	Twist 30	29·9	59·25	20·9	60 pts. off
				,, 36	33·43	50	22·5	
				Weft 24	23	53·25	15·78	
				,, 28	25·56	52·75	17·18	

FEBRUARY 1925—*concld.*

Firm making test	Growth	Bale No	Per cent. loss up to card sliver, including invisible loss	Nominal counts		Actual counts at spindle point	Lea strength test in lb.	Actual turns per inch	Estimated value compared with price of current month futures (universal standard)
No. 2	289 F (Punjab-Am.)	22	18·23	Twist	30	28 71	68 62	20·9	125 pts. off
				,,	36	32 56	55 37	22 5	
				Weft	24	21 81	71 50	15·78	
				,,	28	24 06	57·25	17·18	
	Cambodia .	3	10 09	Twist	30	29 34	54 5	20 9	25 pts. on
				,,	36	33 06	45 5	22 5	
				Weft	24	23·75	58 5	15·78	
				,,	28	25 50	59·5	17·18	
No. 3	*Middling American*		*9 63*	*Twist*	*19*	*20 14*	*77 12*	*15 95*	*15 pts on*
				,,	*12*	*12 86*	*137 25*	*12 55*	
				Weft	*20*	*21 42*	*62·25*	*11 50*	
				,,	*14*	*14 77*	*108 12*	*11 10*	
	Karunganni .	8	10 6875	Twist	16	17 80	78 50	15 15	200 pts off
				,,	10	11 54	132 75	12 10	
				Weft	22	24·05	43 37	15 85	
				,,	10	11·47	59 62	9 25	
	1027 ALF (Surat)	7	10 125	Twist	16	16 92	101 60	14 60	pass
				,,	12	12 86	138 75	11 80	
				Weft	15	16 67	100 12	12 70	
				,,	14	15 21	108·25	11 35	
	Sircar 14 .	1	15 875	Twist	16	16 73	114 62	14 80	100 pts off
				,,	10	10 68	204 25	11 30	
				Weft	20	21 39	82 00	14 55	
				,,	14	15 10	121 12	11·60	
	Sircar 25 .	R1	10 50	Twist	20	23 00	58 37	16 45	50 pts. off
				,,	16	17 65	84 87	15 05	
				Weft	18	20·58	62 75	13 05	
				,,	16	17 99	76·25	13·35	
No. 4	*Boweds American*		*10 2*	*Weft*	*24*	*23 57*	*15 27*	*15·91*	*25 pts. on*
				,,	*20*	*21 07*	*51 37*	*14·5*	
	Karunganni .	9	11·3	Weft	24	23 88	33·75	15 91	150 pts. off
				,,	20	20 93	42·25	14·5	
	Sircar 14 .	R2	10 88	Weft	24	23·66	60·70	15·91	100 pts. off
				,,	20	20·81	69·12	14 5	
	Gadag No. 1 .	4	16·75	Weft	24	22·28	68	15 92	75 pts. off
				,,	20	20·53	74	14 53	

SPINNERS' COMMENTS. NO. 1 FIRM.

	On the raw cotton					On behaviour in working	On the yarns produced
	Staple (in.)	Seed and leaf	Colour	Ginning	Generally		
1027 ALF (Surat)	$1\frac{1}{16}$	Comparatively free	Good white to cream	Good	Very desirable cotton, but attention should be given to developing staple	Worked fairly well	This sample is very little inferior to this seasons's Strict Middling American and slightly brighter in appearance
Dharwar No. 1	$1\frac{3}{32}$	Comparatively free	Cream	Good	The colour will prejudice general use, and whiter strain should be cultivated	Worked well	Equal to Strict Middling Boweds in every respect except colour
Cambodia	$1\frac{3}{32}$	Comparatively free	Creamy	Good	The cotton is of a nice silky variety, but value would be increased if colour could be made more like American	Worked well	Very little to choose for even thread or cleanliness. The sample is a very desirable cotton in every respect except colour

SPINNERS' COMMENTS. NO. 2 FIRM.

	On the raw cotton					On behaviour in working	On the yarns produced
	Staple (in.)	Seed and leaf	Colour	Ginning	Generally		
285F (Punjab Am.)	$1\frac{1}{16}$	Too much of both. Also crushed seed with oil stains	White	Not good	This cotton is strong, less neppy than 289F, but lossy.	Did not spin well (uneven and neppy)	This 285F is in many respects like 289F, but is better ginned and does not contain so much trash. It is brighter and a better colour than 289 F, but inferior generally, although slightly longer in staple. Stronger in pull than American Texas after allowing for coarse counts. For weft it will spin higher counts than those tested, but it needs to be better ginned and grown from a seed which will give a more even running staple
Cambodia	$1\frac{1}{32}$	Satisfactory	Cream	Satisfactory	This type is nearest to the American-grown cotton	Spun and looks more like American than others tested	This type (Cambodia) spun well. It is much like the Texas against which it was tested. It is the nearest in value to American, and could be used extensively if grown in quantity and kept equal to this bale. Comparing the counts and strength per lea with the American, there was little in them, but 30s T is quite far enough to make a really satisfactory twist yarn. It will spin 32s weft with a low draft

SPINNERS' COMMENTS. NO. 2 FIRM—*concld.*

	On the raw cotton					On behaviour in working	On the yarns produced
	Staple (in.)	Seed and leaf	Colour	Ginning	Generally		
289F (Punjab Am.)	$1\frac{1}{16}$	Bad	Dull white or grey	Poor	The waste loss is very heavy. The cotton is strong and free from excessive moisture. Bad for neps	This type is very neppy and spun the worst of the types sampled	Spinners on all counts were unanimous that this type was the worst spinning cotton. Whilst it was longer in staple than other types, its hard character made it the worst spinning cotton even with standard turns in. Its worst features are its neppy character, unevenness, and great waste loss. Taking $13\frac{1}{2}$d. as the value of the F.M. Texas American Cotton it was tested against, it would require to be 2d. per pound cheaper in price for waste loss alone, to say nothing of the inferior yarn it produced in other respects.

SPINNERS' COMMENTS. NO. 3 FIRM.

	On the raw cotton					On behaviour in working	On the yarns produced
	Staple (in.)	Seed and leaf	Colour	Ginning	Generally		
Karunganni	$\frac{15}{16}$	Clean	Good and bright, slightly creamy	Fairly well ginned	This cotton is of a very soft nature with very low natural twist. Requires highly twisting to get anything approaching strength of (Universal) Middling American cotton. Suitable only if used alone for very soft yarns about 20s. Worth cultivating for mixing with American	Worked badly with normal conditions; improved with extra twist	Suitable only if used alone up to 20s in soft spun yarns. A nice even yarn; in appearance equal to one spun with American cotton but would fail by reason of lack of strength
1027 ALF (Surat)	$1\frac{1}{16}$	Slight leaf, but cleans easily	Creamy and bright	Good	Very useful cotton, and large quantities could be used in Lancashire. Fully equal in value to (Universal) Middling American	Very good	This cotton makes a clean, bright yarn of a marketable medium quality. Suitable up to 30s twist and 40s weft.
Sircar 14	1	Large amount of small leaf	Creamy	Too much leaf left in	A cotton worth cultivating, but should be sent in cleaner condition. If this was done the cotton would be fully equal to Universal Middling	Good	This cotton produced a good yarn, very strong and even, but rather too much leaf. It is capable of being spun to 36s twist and 40/44s weft of medium quality.
Sircar 25	1	Very clean	Creamy	Fairly well ginned	A cotton worth cultivating. It is slightly below Universal Middling in value, but would be very useful in Lancashire	Did not work well owing to harshness of fibre and difficulty in introducing twist	Makes a clean, bright and even yarn of moderate strength. Compares reasonably with medium quality American yarn. Suitable up to 20s twist and 30s weft

SPINNERS' COMMENTS. NO. 4 FIRM.

	On the raw cotton					On behaviour in working	On the yarns produced.
	Staple (in.)	Seed and leaf	Colour	Ginning	Generally		
Karunganni	$\frac{15}{16}$	Contains full unbroken seeds, but only slightly leafy	Beautiful creamy white	Too many full seeds, otherwise fairly good	A very nice Indian cotton of fine texture, good colour, bright, and fairly clean, but too short in staple to spin by itself counts higher than 18s to be of commercial value	Very poor spinning, cotton being too soft; will spin up to 18s counts, but to do this will require many extra turns in twisting in both card-room and spinning-room	—
Sircar 14	$1\frac{1}{32}$	Fairly free from both seed and leaf	Bright but creamy colour similar to Cambodia	Good	A very nice class of Indian cotton. Fine silky texture. Good in colour, staple, brightness, cleanliness, and regularity. Similar to good class Cambodia. A fair substitute for American Boweds cotton. Will spin by itself into 22s counts of commercial value	Fairly good spinning cotton up to 22s counts. Does not require any extra twisting in card-room, but does requre extra twisting in spinning room.	—
Gadag No. 1	1	Very leafy and much broken seed	Rather dull and creamy	Not satisfactory (too much broken seed)	Fair staple, fine texture. brightness and cleanliness *not satisfactory*. Too short in staple to spin finer than 24s counts by itself to be of commercial value	Good spinning cotton, run in both card-room and spinning-room with same turns as Boweds American. Its peculiar feature is that it leaves quite a quantity of loose fly or fibre on the roller beam of the spinning mule	Will spin nicely up to 24s counts.

[*The Empire Cotton Growing Review*, II. 2.]

SOUTH AMERICAN LEAF DISEASE OF PARA RUBBER.

Mr. R. D. Rands, Pathologist in Rubber Investigations of the Bureau of Plant Industry of the United States Department of Agriculture, has recently published in Department Bulletin No. 1286 a note on the present knowledge of this disease. It was first reported in 1904 from material collected from wild trees of *Hevea brasiliensis* in the upper region of the Amazon and subsequently has been found in the lower valleys of the Amazon as far as Para, in the British and Dutch Guianas and in Trinidad, and its distribution is probably coincident with that of the native *Hevea* species. It occurs both on wild and cultivated *Hevea brasiliensis* and also on two other species of *Hevea, viz., Hevea confusa* and *Hevea guyanensis*, but it has never been reported to attack any other plant than *Hevea*. At first it was looked on as a nursery trouble and a disease of secondary importance, but in a very few years it has spread in the local plantations and practically ruined the local industry.

Description of the disease. The leaf disease appears first on the tender, pendant, very young (3 to 5 days old) leaves as opaque olive-green spots, 1/25th to 1/5th inch in diameter, on the naturally translucent reddish brown surfaces of the leaflets. When many spots develop the leaflets soon blacken, shrivel up, and fall off, followed in a few days by the long naked petioles. A severe general attack at this stage gives much the same impression as a case of *Phytophthora* leaf fall, except, of course, that it is confined to the very young leaves. Since, following the annual " wintering " period, the trees put out new leaves over the entire crown or at least over entire branches at approximately the same time, it is clear how a severe attack of the disease at this crucial stage can cause complete defoliation. In the course of four to five weeks after the first defoliation the trees have again put out a new crop of leaves, which in turn may be killed and drop off. Thus, the planting appears to be continuously going through the "wintering " process. Stahel in Dutch Guiana found that three successive defoliations, occurring over a period of about six months, were sufficient to cause a general dying back of the entire crowns of 5 to 6 year old trees. This die-back, which is generally an indication of the presence of the leaf disease in a planting, was shown to be due to local starvation resulting from depletion of the starch reserves, first in the smaller branches and finally, with repeated defoliation, in the larger limbs and even in the trunk itself. Reduction in the yield of rubber follows closely the exhaustion of reserve food materials, so that after a few defoliations tapping becomes unprofitable.

Less severe attacks of the disease usually cause only the shedding of occasional leaflets, which, combined with more or less stunting of the remainder, gives the foliage a peculiar thin appearance. When only a few spots develop on a very young leaf, the unaffected portions continue to grow and cause a characteristic crumpled appearance. The subsequent falling out of the diseased portions, especially of the marginal ones, on such leaves gives them a ragged shot-hole aspect, which persists until

the following "wintering" period. This frayed-out condition is typical of a mild attack, and where not many of the leaflets actually drop off it has apparently little or no appreciable effect on the yield of latex.

Naturally all degrees in severity of attack may be observed, but the symptoms above described develop especially when infection occurs on very young leaves, 1 to 3 days old. According to Stahel, leaves more than a week old rarely become infected at all. Even before this the tissues have already become firm and more resistant to penetration by the fungus, so that the resulting lesions are quickly delimited, often somewhat hypertrophied, and usually small 1/25 to 1/6 of an inch in diameter, with sometimes a dead papery centre. Although large numbers of these minute spots may develop on a single leaflet and cause considerable stunting, death rarely results.

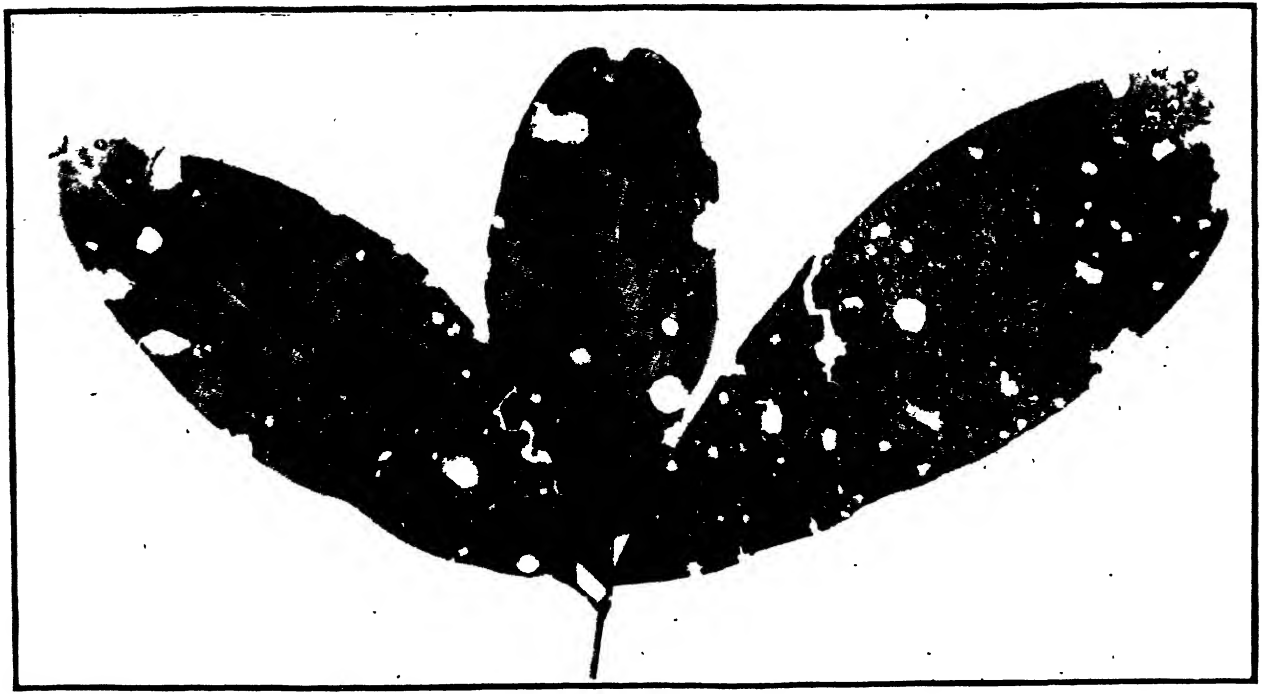
The under surface of both large and small spots has at first, under moist weather conditions, a velvety grayish white appearance from the millions of spores of the fungus produced on slender stalks arising from the diseased leaf tissues. Later, over the centre of the smaller spots or around the margins of the larger ones on the upper leaf surface, minute black points appear, which represent the further fruiting stage of the fungus. On account of their position around the spots these little points often form nearly complete rings, which are very characteristic of this disease on full-grown leaves.

Young twigs, flowers, fruits, leaf stalks, and fruit stalks are also attacked, causing black hypertrophied areas or cankers.

The fungus that causes this disease has three kinds of spores. One kind develops in enormous numbers mainly on very young leaves or other tender succulent parts, such as leaf stalks, flowers, flower stalks, and young twigs, is readily carried by the wind from tree to tree and easily penetrates other young organs. The other two kinds of spores appear later but as far as is known do not play an important role in the spread of the disease. Germination and successful penetration of the susceptible leaf can occur only after moisture has been present continuously for 10 to 12 hours, but leaves more than a week old are no longer susceptible. Once inside the leaf the fungus spreads in all directions and after a period of about 5 days the first external symptoms of the disease may be observed, while one or two days later spores appear. Thus in less than a week the fungus is able to reproduce itself, a fact which explains the very rapid spread of the disease under favourable conditions.

The bulletin is very well illustrated and contains graphic descriptions of the havoc caused by the disease in various regions. It is well worth perusal by every one interested in *Hevea* cultivation. Some talk has arisen about there being other varieties of *Hevea brasiliensis* that give a better yield of latex than those now cultivated on estates in the East, and it is just possible that some one may have an opportunity of importing fresh seed. Though the disease has not been reported to occur on seeds or on capsules, yet it is quite possible that it may occur on the latter, and care would have to be exercised in handling the imported seed and its packing and in the choice

PLATE XX.



TYPICAL SYMPTOMS OF THE DISEASE ON THE MATURE LEAF.

Although infection doubtless took place when the leaf was very young, growth in this case continued, resulting in a stunted, shot-hole appearance. The affected portions have died, and around the margins of the holes and spots black fruiting bodies of the fungus have developed. (Natural size).

MAGNIFIED PORTION OF A LEAF, SHOWING DETAILS OF THE STROMATIC RINGS.

The black masses and circles consist of large numbers of minute spherical fruiting bodies of the fungus, the pycnidia and perithecia. They break through the upper surface of the leaf and may occur singly or fused laterally in groups, arranged around the border of the spot. (Magnification × 7).

of a place in which to grow the plants, in order not to add this far more destructive disease to the already too familiar second leaf fall. The disease has already been notified under the Destructive Insects and Pests Act of 1914, and seeds of *Hevea* can be imported into India from America (including the West Indies), only through the agency of the Madras Department of Agriculture. [W. McRae.]

SECOND PLANT BREEDERS' CONFERENCE IN BOMBAY.

The Conference met again this year at Surat on 26th, 27th and 28th February, 1925, under the presidency of Mr. R. K. Bhide, Crop Botanist to the Government of Bombay, Poona. There were about 35 members present including Dr. W. Burns, Economic Botanist and Principal of Agricultural College, Poona; Mr. Youngman, Cotton Botanist, Central Provinces; Rao Saheb Bhimbhai M. Desai, Deputy Director of Agriculture, Gujarat; Mr. V. G. Gokhale, Deputy Director of Agriculture, Konkan; Messrs. Thadani, Kottur, Patel and Prayag, Cotton Breeders; and others engaged in breeding other crops.

The following subjects were discussed :—

(1) Probable error of field experiments. (2) Sarkar's method of estimating the results of trial of types. (3) Results of comparing strains by the different formulæ for calculating probable error. (4) Stability of the performance standard of the improved varieties under the cultivator's conditions. (5) An attempt to standardize for different crops the exact method of testing the alleged improvement. (6) Competition effects of two cotton strains. (7) A preliminary note on natural cross pollination in Jowar. (8) Influence of mass selection on the improvement of crops. (9) Influence of competition between adjacent varieties or strains. (10) Acclimatization and adaptation of newly imported seeds. (11) The problems of sterility and fertilization in crops.

There was a considerable presentation of data and a good deal of discussion on most of the subjects, and the following conclusions were arrived at :—(1, 2 and 3) "Last year's findings as to the arrangement of plots, and the formulæ to be used for the probable error, were generally confirmed and recommendations were made to study recent literature regarding the practice and theory of probable error (including Mr. Mahalanobis's paper)." (4) "The improved races had generally retained their superiority under cultivator's conditions. To minimize fluctuation, adaptability to a large range of conditions should be the ideal in breeding improved races. Breeders should aim at producing races with very marked differences from the local." (5) "The method for testing the alleged improvement should involve (*a*) testing on a big scale, (*b*) trial in the district, (*c*) replications of improved strains on cultivator's plot alternating with cultivator's own seed, all such testing to be under

Government supervision and control." (6 & 9) "Unless we have proved the non-existence of different competition effects, it is desirable to discard side rows while comparing yields of adjacent plots as in the case of replications. But where it is proved that different competition effects do not exist this precaution may be omitted." (7) "Though certain colour characters of the F_1 hybrid may not always be suitable for detecting crossing, still the simultaneous occurrence of three dominant characters in the progeny of a plant which lacked them before as in Mr. Patel's experiments might be a safe guide to detect crossing." (8) "For tracts where no improved pure seed has been distributed to cultivators, mass selection at least in the case of grain crops might be useful to the cultivators. But some guidance should be given to them as to what characters they should take into consideration in such selection." (10) "Acclimatization was a fact. It might be (*a*) selection by climate of like individuals from an obvious mixture, and (*b*) selection by climate of a physiologically suitable race from a variety apparently pure for external characters or the gradual adjustment of some individuals of a variety to a new environment, and it is desirable to consider each case on its own merits." (11) "The Conference recommended that further data of all kinds of sterility should be gathered."

Among others, the follow'ng resolution was passed :—"That a recommendation should be made to the Director of Agriculture that the next Conference of the Plant Breeders should meet in Sind and that Mr. Thadani should be the President of the next Conference."

CUTTING SEED POTATOES.

Potato growers frequently hesitate to cut their seed potatoes on account of the uncertainty as to the yield per plant and to the growth and healthy development of the cut sets. This second point has been investigated by J. H. Priestly and G. C. Johnson (*Jour. Min. Agri.*, XXXI, No. 11) who indicate the precautions needed to eliminate this uncertainty. The healing of the cut surface of a tuber is brought about by the deposition of a suberin deposit, which forms a barrier to the entry of moulds and bacteria capable of attacking and rotting the tuber. If the potato is cut in moist air this suberin layer is continuous over the whole surface, but if the air be dry the suberin is patchy and organisms are able to penetrate through the cracks between the patches, thus damaging the tuber. Field trials have proved the importance of this fact. Similar tubers of Great Scott were cut and exposed to sun and air for 24 to 48 hours, or kept in a damp, warm place for the same time. Much heavier crops were obtained with the latter treatment, 15½ tons against 6½ tons, 23½ tons against 14½ tons, etc., similar results being obtained with other varieties in other districts. Apart from the question of yield, it appears that the certainty of growth from cut sets is much greater if precautions are taken to protect the sets from sun and wind after cutting before they are planted. [*Nature*, No. 2888.]

EFFECTS OF CLOSE INBREEDING.

The largest-scale inbreeding experiment ever conducted has failed to show any disadvantage in the mating of close relatives, provided the stock is good to start with, according to results just announced at the Wistar Institute of Anatomy and Biology of the researches of Dr. Helen Dean King.

Dr. King's investigation dealt with the data for twenty-five successive generations of albino rats, comprising over 25,000 individuals, that were obtained by the closest form of inbreeding possible in mammals—the mating of brother and sister from the same litter.

Comparisons made between inbred and stock animals, reared under similar conditions of environment and of nutrition, show unmistakably that inbred rats are larger, more fertile, and that they attain sexual maturity earlier and possess greater vigour of constitution than do stock animals.

The conclusion is drawn that inbreeding, *per se*, is not injurious, provided that the animals inbred are of sound stock and that there is a careful selection of the individuals that are used for breeding. [*Science*, N. S., LX., No. 1565.]

EFFECT OF SOAKING GARDEN SEEDS BEFORE PLANTING.

Soaking garden seeds to give them a running start also increases their speed through life, according to reports from the Plant Breeding Station at Proskau. Germany. Radish seed soaked for two or three hours in a solution of magnesium chloride or magnesium sulphate give an increase in leaf and root development and a more than tripled yield in the most striking of the treated plants. Even soaking in pure water more than doubled the yield. Officials of the U. S. Department of Agriculture state that simply taking precautions to start with disease-free seed may lead to a false impression of stimulated growth. The department has been studying the effects of chemicals in destroying seed-borne parasites. Treated seeds may lead to normal healthy plants and such merely healthy plants may give the impression of leading a faster life when compared with sister plants from untreated seed. The Department of Agriculture is now launched on experiments which will determine whether there is a genuine speeding-up of the life of plants from the soaking of seed as the Proskau experiments suggest. [*Science*, N. S., LX., No. 1562.]

THE AMERICAN COTTON CROP REPORTS OF NOVEMBER 21 AND DECEMBER 9, 1924.

Prof. John A. Todd writes in *The Textile World*, Vol. LXVI, No. 26 :—

The two cotton reports as of November 14 and December 1, published November 21 and December 8, mark an important difference from their predecessors. Up

till November 1 the indicated crop in each report was described as a "forecast," but that of November 14 for the first time appeared as a "preliminary estimate" and that of December 1 takes the place of the first crop estimate which used to appear each year on December 12. The difference is more than one of names. The crop forecasts which have appeared this year in every Bureau report since August 16 are, as the department has repeatedly pointed out, not crop *estimates* at all but simply "arithmetical interpretations" of the state of the crop *at the time*, obtained by applying the condition percentage to the par value or supposed 100 per cent. yield for each State. Thus the crop forecasts do not pretend to state what the ultimate crop is going to be, but simply what the crop is looking like at the time of the report.

The December estimate, however, is an entirely different thing. It is really an estimate of the final outturn of the crop, because by December sufficient information is available in the ginning reports to show how the crop is actually turning out, and the element of guess-work as to how much of the crop still remains to come in is reduced to a very small proportion.

The unexpected thing, however, is that the report as at November 14 was described as a "preliminary estimate," and that "this estimate is based on the reports of voluntary correspondents, field statisticians and co-operating State Boards (or departments) of Agriculture and Extension Departments, covering the condition, probable yields per acre, per cent. of acreage abandoned, per cent. of the crop picked and ginned, etc., and upon the actual ginnings to November 14 as determined by the United States Census Bureau." It has, therefore, to be placed in an entirely different category from its immediate predecessors, and this is emphasized by the fact that neither condition figure nor par values were published, the Bureau apparently having switched over from that method of calculation to the other method of direct estimation. The reason for this change presumably is that the Bureau had no record of par values for previous years beyond, at the very latest, October 25. What it comes to in effect is that the attempt to extend the system of condition reports beyond October 25 has proved ineffective this year, through the lack of previous records for comparison.

What they tell us.

Keeping in view this distinction, however, the practical question is what these new reports tell us. Perhaps the best way to get a general view of the whole situation is to study the history of the season as shown by the various Bureau reports. The accompanying table gives a record by States of the indicated crop according to each Bureau report since August 16; and for the sake of completeness we have carried the record back to June 25 by calculating the indicated crop from the data (condition per cent. and par value) supplied by the Government, though they apparently did not think it advisable to make that calculation themselves and publish the result. For the July 16 report the par values were never published, so that we are unable to make this calculation by States, but the total figure is given.

The main point in this table is that the estimate for Texas and Oklahoma shows a total of 6,220,000 bales compared with their total in the Bureau report of September 16 last of 5,499,000 bales, so that about 720,000 bales have been added to these two States since the drought broke in September.

The question now, therefore, is whether the Bureau in thus steadily raising their figures, especially for the States where a top crop is probable, have allowed sufficient for the effects of the fine weather of the last two months. The fact is that as far as the weather is concerned, this year is almost exactly following the unusual experience of 1920. In that year the last crop forecast as at September 25 was 12,123,000 bales, while the estimate in December was 12,987,000, and the final outturn of the crop 13,440,000 bales. Is there any possibility of similar developments this year ? Many people here have quite definitely taken the view that there is not only possibility but probability, and some of them argue that a crop of 13½ millions or even 14 millions is definitely assured.

This opinion seems to be largely based on the heavy ginnings to date, which are also shown in the table. But there is one method of testing this opinion, namely, by comparing the ginnings to December 1st for each State with the crop estimate for the State as at that date, and considering State by State whether in view of what is known about the progress of the harvest in each case the apparent balance unginned shown by these figures is likely to be greatly exceeded. Thus, according to the table, the balances are very small except in Texas, Oklahoma, Arkansas and North Carolina. In some other cases the balances certainly seem very small but such comparisons are always rendered difficult by the confusion between the crop estimates which are in bales of 500 lb. gross (478 lb. net) and the ginning figures which are in running bales. We have no details here yet of the average bale weight for each State, and that for the Belt as a whole (499·8 lb.) is entirely deceptive when applied to individual States.

With regard to the acreage it appears that the original estimate of acreage planted has been raised from 40,403,000 to 41,390,000, but of this 3·1 per cent. has been abandoned, leaving the first estimate of acreage harvested 40,115,000 acres. Upon this figure the present estimate of the crop would show an average yield per acre of 156·8 lb., which is the best since 1920. That is perhaps the most convenient figure to sum up the whole position of the 1924 crop. The question all the way through this season has been whether it would follow the precedent of its three evil predecessors or whether it would go back to the example of the last good year 1920. The answer is that it has done its best to follow 1920, and it has had the same good luck in one respect at least, namely, the wonderful harvest weather ; but for all that the average yield is more than 20 lb. less than in the last banner year.

American Cotton

State	Acreage (000's) planted June 25	Forecasts (000's 500 lb. bales) as at calculated from Government data official figures					
		June 25	July 16	August 1	August 16	September 1	September 16
Virginia	92	35		31	38	*41	39
North Carolina	1,822	*945		754	795	828	782
South Carolina	2,185	*835		765	803	767	728
Georgia	3,767	987		1,081	1,185	*1,209	1,198
Florida	111	22		23	25	27	29
Alabama	3,190	863		904	989	948	956
Mississippi	3,256	1,038		1,009	1,039	1,033	1,055
Louisiana	1,537	475		378	360	371	398
Texas	15,595	4,179		4,349	4,433	4,284	4,237
Arkansas	3,058	957		1,031	1,112	1,109	1,056
Tennessee	1,184	381	(No par values)	403	*436	421	413
Missouri	453	*179		224	222	*228	212
Oklahoma	3,672	995		1,146	1,255	1,289	1,262
California	126	69		70	*71	61	63
Arizona	179	113		*44	106	89	90
New Mexico	140	61		64	*71	65	60
Others	36	10		5	16	17	18
Add Totals	40,403	12,144	11,934	12,351	12,956	12,787	12,596
Ave Lower California	140	..	..	..	79	68	70
Averages	..	143·8	141·3	146·5	153·5	151·5	149·2

Crop, 1924-25.

			Estimates		Ginnings to December 1			
					1923		1924	
October 1	October 18	November 1	November 14	December 1	Total	Balance	Total	Balance
35	36	33	30	30	38	14	21	9
723	750	770	760	765	941	112	674	91
671	680	715	720	750	750	44	748	2
1,118	1,050	1,030	990	1,000	582	31	978	22
*32	27	27	27	22	13	1	19	3
959	970	980	980	*990	584	15	953	37
1,113	*1,135	1,120	1,110	1,080	594	29	1,077	3
423	450	450	465	*480	356	18	471	9
4,255	4,350	4,450	4,650	*4,770	3,919	293	4,423	347
1,068	1,130	1,150	1,125	1,100	563	81	979	121
492	400	365	350	330	200	35	296	34
201	200	190	160	146	88	37	126	20
1,272	1,275	1,300	1,390	*1,450	508	158	1,285	165
60	59	65	61	*71	33	22	49	22
95	92	95	100	100	52	26	78	22
55	54	56	74	56	23	12	40	16
17	17	*20		13			7	6
12,499	12,675	12,816	12,992	*13,153	9,243	928	12,225	928
66	64	62	68	63	..	..	..	..
148·0	150·1	151·6	153·7	1·568	..	..	..	..

* Maxima.

COTTON NOTES.

THROUGH the courtesy of the British Cotton Industry Research Association, the Secretary of the Indian Central Cotton Committee has sent the following abstracts for publication :—

RIGIDITY OF COTTON HAIR.

The rigidity of raw cotton hairs has been measured by a method previously described (L. 1923. 3) but under conditions of closely controlled humidity at 20° C. Each hair was examined at a number of different humidities and the results on all the specimens compared by expressing the observations as ratios to the rigidity at 50 per cent. relative humidity. The relation between rigidity and humidity is then expressed by an S-shaped curve, the value at saturation being less than one-sixth that in dry air. The decrease is rapid in the first and last 10 per cent. regions, whilst the middle portion shows an approximately regular decrease with increasing humidity. Over the range 3-83 per cent. relative humidity the relation is sufficiently well expressed by a given linear equation. When the logarithm of the rigidity is plotted against the moisture regain (C. 1924. 39), the points lie on a straight line the slope of which shows that the rigidity is halved by the addition of 10 per cent. of moisture and may be expressed by a given exponential formula. Increase of temperature decreases the rigidity at constant moisture regain, and this is only partly counteracted by the decrease of absorbed moisture when the relative humidity remains constant. The effect of temperature is of a lower order than that of humidity in the limits of variation normally encountered. In saturated air, the rigidity appears to increase with change of temperature above or below 20° C. Using previous results (L. 1923. 3) and an approximate correction for swelling, the variation of the rigidity modulus is evaluated. [*Jour. Text. Inst.*, 1924, **15**, T. 501-518. F. T. PEIRCE.]

STRESS/STRAIN RELATIONSHIPS OF COTTON HAIR.

The author has determined the changes in dimensions of single cotton hairs under longitudinal stresses in relation to the time of application of the loads. Cotton hairs in water when loaded longitudinally exhibit an irregular extension, equilibrium being attained in 5,000-10,000 minutes with stresses of the order of 108 dynes/sq. cm., though tendency to a temporary equilibrium at ½-2 hours is frequently manifested. The stress/strain value sinks to 0·74 of its value at 1 hr. in the subsequent period. The recovery from strain is a smoother process. The fractional permanent loss of sectional area is greater than the fractional permanent longitudinal strain. With stresses of this order, application of the load for a few seconds is sufficient to effect permanent strain. Under fixed conditions of stress and time of application a reversible cycle is attainable by repetition. Increase of time of application or stress pro-

duces further permanent strain. Hairs loaded to equilibrium likewise exhibit elastic behaviour after one or two cycles,the stress/strain value rising to a constant. Reference is made to the practical application of these results. [*Jour. Text. Inst.*, 1924, **15**, T. 518-528. G. E. Collins.]

Adulteration of Sakellaridis Cotton.

The Egyptian Ministry of Agriculture has decided to ensure the maintenance of pure commercial types by an extensive propagation of selected State Domain strains. The available stocks of seed will be supplied only to cultivators of large areas with a reputation for excellent farming. Under supervision, all rogue and impure plants will be removed, and the mixing of seed at the ginneries will be prevented by official inspection. The permanent adoption of this seed farm system will make certain an abundant supply to meet the requirements of all Sakel growers in future years. Pure strains of Assili, "310," Royal Ashmouni and Zagorah will be increased in the same way. This information is supplied by the Royal Egyptian Legation in London, in reply to the rumours concerning the impossibility of obtaining pure Sakel seed for the forthcoming season. [*Manchester Guardian*, 5th Jan., 1925, p. 3, col. 5.]

Control of Pink Bollworm in Sudan.

Where American and Egyptian cottons are grown, the burning of old crop sticks and refuse and of Bamia (an alternative host) by a fixed date in each district is enforced. Combined with sowing restrictions which fix the date for sowing and prevent the use of any but approved seed, a two months " dead season " is assured. During this period, all forms either still on the ground in bolls or hidden in cracks in the soil are effectively destroyed by the baking power of the sun. All seed is spread in a thin layer on the ground and subjected to the action of heat from the sun. In practice, the seed is usually kept at a temperature of 65° C. from two to three hours, though an exposure for one hour at 50°C. is sufficient to destroy the bollworm larva. The seed cotton retained by the villagers for local hand spinning (Damur cotton) is the only source of infection for which no general provision is as yet made. In the Nile Province, however, an experiment has been tried in areas suitable for American, by which cotton areas are established and the natives are compelled to gin their home supplies by a fixed date. All seed is then collected by the central authorities and destroyed or sold according to its quality. The natives are recompensed and American seed is also issued to them for their next sowings. By this means in the closed areas all larvæ in seeds are destroyed and in addition the gradual displacement of Beladi, the native type, with the more valuable and exportable American type is assured. In addition to the present " dead season " regulations, the adoption of this plan is recommended throughout the irrigation areas already producing cotton and also in the rain regions as cotton growing extends. [*Wellcome Tropical Research*

Laboratories, Entomological Section, Bull. 21, May 1924, pp. 16. H. H. King and W. E. Giffard.]

Cotton Cultivation in U. S. A.

The following new areas in the south-west suitable for cotton growing are discussed.

(1) *The "South Plains" district of W. Texas.* This is a stretch of 150 miles of original prairie, from the Panhandle and Amorillo in the north to Abilene in the south, about 30 to 75 miles wide, and with an average altitude of 3,200 feet. Lubbock occupies a central position and within 100 miles there are roughly 8 million acres of suitable land. In 1909 only 9,000 bales of cotton were produced, but in 1919 the yield was 132,000, and in 1923, 554,000, only sorghum being of greater importance. The soil is a dark sandy loam. The average rainfall is only about 21 inches per annum and the frost-free period is very variable (166 to 246 days), so that farmers only count on three good seasons in five. However, the boll-weevil danger is absent and cultivation is so easy that one family can manage 100-160 acres; the costs of production are actually lower than anywhere else in the States. The usual type sown is Mebane, giving a ginning outturn of 35 per cent.; the lint is very strong and 10 per cent. is 1 inch staple, 70 per cent. $1\frac{1}{16}$ inch and 10 per cent. $1\frac{1}{8}$ inch. Seed is sown from 5-20th May, and picking begins in mid-September and continues until the first killing frost; if this arrives early the proportion of "bolly crop" is high. The plants are left unchopped in the rows and the yield is about one quarter of a bale per acre.

(2) *The Pecos River Valley.* In this region of S. W. Texas, developments depend on irrigation schemes, seven already being under way which will eventually provide water for 125,000 acres. Another scheme including a large dam at Red Bluff would irrigate enough land to grow 100,000 bales of excellent cotton. In the Grand Falls district, 2,500 ft. above the sea, irrigation water is available only between January and April. After one heavy soaking, the land is ploughed and the seed is sown in the furrows. With the help of $1\frac{1}{2}$-2 inches of rainfall, and by careful dry cultivation methods, the plants grow to about 4 feet and generally produce from $\frac{1}{4}$ to $\frac{1}{3}$ bale per acre. Acala cotton with staple $1\frac{1}{8}$-$1\frac{3}{8}$ inch is the usual type. The boll-weevil cannot survive the dryness, but the pink bollworm is sometimes found; rabbits do most damage. About Barstow, two extra summer waterings are possible and Mebane is grown as much as Acala.

(3) *Upper Rio Grande and Mesilla Valley.* In this almost rainless region, the Elephant Butte irrigation scheme waters 175,000 acres. In 1924, 73,000 acres were under cotton, estimated to yield 55,000-60,000 bales. Acala with staple $1\frac{3}{16}$ inch forms 95 per cent. of the crop. El Pasco in Texas is the chief market and here the seed is fumigated against pink bollworm. Further up the valley, at Las Cruces, which is a market of growing importance, yields as high as $1\frac{3}{7}$ bales per acre have been obtained. [*Leipzig. Wochenschrift Text. Ind.*, 1924, **39**, 1087, 1112.]

Cotton Plant Disease.

Specimens of young cotton bolls which had been shed at various stages of development up to one-quarter inch in diameter have been examined. Many of the bolls showed elongated, depressed lesions, covered with the pink conidia of *Colletotrichum gossypii*, on the portion of the pedicels immediately beneath the bracts. In other instances the basal portions of the young bolls were attacked and discoloured. The infection is believed to have originated round punctures made by boll weevils which presumably acted as disseminating agents. This is believed to be the first record of boll shedding due to *C. gossypii*. [*Rev. Appld. Mycology*, 1924, **3,** 703 ; from *45th Ann. Rep. N. Carolina Agri. Expt. Sta.*, 1922, pp. 74-76. F. A. Wolf.]

Cotton Production in Natal (North).

The Candover Estates, Ltd., report 9,600 acres under cotton this season, and a crop of 250 lb. per acre is expected. For all cotton planted before 15th December, 1923, the total cost of production per lb., including all marketing costs, was 7·391 *d.*, the corresponding figure for the previous season being 8·250 *d.* Considerable reductions in these costs are anticipated with further expansion and when the new railway running through the Estates is constructed. The average profit for the year ending June 30th, 1923, was 10·04*d.*, per lb. with an average selling price of 18·293 *d.* per lb. The corresponding figures for last season were 11·459 *d.* per lb. and 18·85 *d.* per lb. Whereas S. African averages about 1 *d.* on American Middling, Candover cotton fetched up to 375 points on. The area owned by the Company is 80,000 acres. (*Manchester Guardian Commercial*, 1925, **10,** No. 245, p. 173.) [*The Cotton News Weekly*, 1925, **2,** 79-80.]

Cotton Cultivation in North Rhodesia.

The new cotton area of Chisamba has 3,000 acres of cotton planted this year. The majority of the seed is Watts' Long Staple and the germination has been good. Rainfall has been fairly heavy and somewhat too frequent. A report from Mazabuka mentions the controversy among the growers of Improved Bancroft, Arizona and Watts' Long Staple, as to the merits of the different types. Bancroft gives a 4 per cent. higher outturn, 32 per cent. as against 28 per cent. for Watts' Long Staple, but the latter yields the longer lint. [*The Cotton News Weekly*, 1925, **2,** 95.]

Pima Cotton Cultivation in South Africa.

In March 1924, 3 bales of Pima were sold at 23 *d.* per lb. in Liverpool, and reports on a further consignment are also very favourable. This type averages a premium of 4 *d.* over Upland ; and it is considered suitable for growth in any part of the cotton belt where the soil is good, the growing period is rather long, without cold nights, mists and frosts, and where suitable irrigation facilities are assured. [*The Cotton News Weekly*, 1925, **2,** 61, 63.]

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

We offer hearty felicitations to Sir James Mackenna, Offg. Member of the Executive Council of the Governor of Burma and formerly Agricultural Adviser to the Government of India, who has been knighted on His Majesty the King-Emperor's Birthday.

The title of Khan Sahib has been conferred on Chaudhuri Muhammad Abdulla, Deputy Director of Agriculture, Punjab, and Munshi Amir Hasan Khan of the Subordinate Agricultural Service, United Provinces, and that of Rao Sahib on Mr. B. P. Vagholkar, Cotton Supervisor, Khandesh Division, Jalgaon.

Dr. D. Clouston, C.I.E., has been confirmed in the appointment of Agricultural Adviser to the Government of India and the Director of the Agricultural Research Institute, Pusa, with effect from 10th September, 1924, the date from which Mr. S. Milligan has been permitted to resign his appointment in the Indian Agricultural Service.

Mr. J. H. Walton, M.A., M.Sc., Assistant Bacteriologist, Agricultural Research Institute, Pusa, has been granted combined leave for 4 months and 7 days from 6th July, 1925.

Mr. R. S. Finlow, B.Sc., F.I.C., Director of Agriculture, Bengal, has been allowed leave on average pay for 7 months and 15 days from or after 10th June, 1925, Dr. G. P. Hector officiating.

The post of a Professor of Agricultural Economics has been created at the Agricultural College, Poona, for a period of 3 years from 1st June, 1925, and Rao Bahadur P. C. Patil, L.Ag., M.Sc., has been appointed to hold it pending further orders. He will also officiate as Principal of the College, *vice* Dr. Burns on leave.

Mr. T. F. Main, B.Sc., has been appointed Deputy Director of Agriculture, South Central Division, Bombay Presidency, *vice* Rao Bahadur P. C. Patil.

Mr. H. G. Baluch, B. Ag., has been appointed to act as Live Stock Expert to the Government of Bombay, *vice* Mr. E. J. Bruen granted leave on average pay for eight months.

Mr. H. R. Stewart, A.R.C.Sc.I., D.I.C., N.D.A., Professor of Agriculture, Lyallpur, has been granted leave on average pay for seven months from 25th March, 1925. Sardar Sahib Kharak Singh has been appointed to act as Professor of Agriculture so far as teaching work is concerned, while Mr. D. P. Johnston has been entrusted with the district work.

Khan Sahib Chaudhuri Muhammad Abdulla, Deputy Director of Agriculture, Punjab, on transfer from Lyallpur, has taken over charge of the newly created Multan (South-west) Circle.

Lala Harnam Das, M.Sc., Offg. Assistant Professor of Entomology, Lyallpur, has been, in addition to his own duties, put in charge of the current duties of the Entomologist to Government temporarily with effect from 21st April, 1925, *vice* Mr. Afzal Hussain on other duty.

Colonel G. K. Walker, C.I.E., O.B.E., F.R.C.V.S., Principal, Punjab Veterinary College, Lahore, has been granted leave on average pay for one month combined with the college vacation, Mr. W. Taylor officiating.

Mr. M. J. Brett, M.R.C.V.S., Superintendent, Civil Veterinary Department, North Punjab Circle and N.-W. Frontier Province, has been granted leave on average pay for 5 months and 22 days from 14th April, 1925, Mr. T. J. Egan officiating.

MR. E. A. H. CHURCHILL, B.Sc., Assistant Director of Agriculture, Central Provinces, has been confirmed in his appointment in the Indian Agricultural Service with effect from 31st January, 1925.

MR. R. F. STIRLING, F.R.C.V.S., Second Superintendent, Civil Veterinary Department, Central Provinces, has been granted study leave for 12 months in extension of the leave already granted to him.

THE fourteenth meeting of the Board of Agriculture in India will be held at Pusa from 7th to 12th December, 1925.

REVIEWS

A General Text Book of Entomology.—By A. D. IMMS. (London ; Methuen & Co., March 1925 ; pages xii +698 ; illustrations.) Price, 36 *s*. net.

ON the general subject of Entomology books a-many fill our shelves and bear witness to the progress of our knowledge of the study of insects. The earlier ones, of the seventeenth and early eighteenth centuries, were usually written in Latin, and are exemplified by Goedart's *Metamorphosis et Historia Naturalis Insectorum* (1662) and Swammerdam's *Historia Insectorum Generalis* (1733), with their quaint illustrations. The introduction of the binomial system, by which all animals were given a generic and a specific name, facilitated the recognition of different kinds of insects so that the second half of the eighteenth century saw the issue of numerous descriptive and iconographic works, of which those of Fabricius and Cramer may be taken as examples. About the same time the use of Latin began to fall into disuse, at least in the case of books on insects of local interest or of essentially popular publications, such as Yeats' *Institutions of Entomology* (1773). These led the way to more detailed books, such as Kirby and Spence's *Introduction to Entomology*, and this period closed about the time of the issue of Westwood's excellent *Introduction to the modern Classification of Insects* (1839). Thereafter there commenced the period of specialization as, with the growth of knowledge, it soon became impossible for any one man to become and keep himself acquainted with progress in all branches of Entomology. Oliver Wendell Holmes drew an intentional caricature in his pen-portrait of the Scarabee, who could not claim to be an entomologist, or even an authority on Beetles, but who devoted himself to one group of these insects only ; but here once more truth has outrivalled fiction and the present day sees the Scarabee himself divided into specialists in various groups of Scarabaeid beetles. The growth of specialization is not, of course, peculiar to Entomology but has proceeded equally in all branches of knowledge, yet it is usually not realized what an enormously large field is covered nowadays by the study of Insects, a field whose boundaries impinge on those of Commerce, Agriculture, Forestry, Medicine, Veterinary Science, Education, Zoology, Geology, Genetics and numerous others. General Text-books on Insects therefore meet a need of all modern entomologists as well as of those with a more general interest in the subject, and this need has been met by the issue of numerous publications of which it would be tedious to give any detailed list. One of the most successful of the English text-books has been Sharp's two volumes in the *Cambridge Natural History* (1895, 1899) but these, though excellent in their day, have been rendered rather out-of-date by the very considerable accessions to knowledge during the last thirty years.

It is, therefore, with considerable interest that the working entomologist examines each new Text-book as it appears to see how far it will help him in his work. Many are merely elementary or popular, some are frankly poor, and others are excellent. In this last category we may place Dr. Imms' *General Text-book of Entomology*, which has just been published, and whose aim, in the author's own words. " has been to present the chief facts concerning the structure, physiology, development and classification of the Insecta and the Biology of their more important representatives......The object throughout the book has been to present before the reader essentials but, at the same time, to indicate where fuller information is available." These objects have been admirably attained, the subject-matter being dealt with in three sections, (1) Anatomy and Physiology, (2) Development, and (3) Classification, each section being fully illustrated and accompanied by adequate lists of literature.

This book comprises 700 pages and is throughout well-written, well-illustrated and well-produced. There are a few minor corrections which will doubtless find their way into a second edition ; meanwhile, Dr. Imms' Text-book should find a place, and largely replace Sharp's volumes, in every entomological library and laboratory. [T. B. F.]

The Auto-regulation of Physiological Processes in Plants. Presidential Address to the Botany Section of the Twelfth Indian Science Congress, 1925.—By R. S. Inamdar, M.A. Pp. 36. (Calcutta : Baptist Mission Press.)

In this paper the author discusses the physical and chemical problems connected with the metabolism and growth of plants. The researches of recent years have been directed towards the extension of the laws, which govern chemical and physical reactions in the non-living state, to include the generally more complex and difficult reactions which take place in the living cell. This is in marked contrast to the older view that the metabolic changes within the living organism were conditioned and controlled by the existence of a special " vital force " without which the phenomena which we recognize as life could not take place. The author gives us a capable and interesting summary of the principal researches of modern botanists which have been instrumental in establishing a mechanistic conception of life. In addition to the well known and classical investigations on optima and limiting factors carried out in Europe, Professor Inamdar is able to communicate some interesting results of his own work on the regulation of the transpiratory process. The author concludes that there is a regulatory effect on the part of the plant to maintain a specific maximum of water loss during physiologically equivalent amounts of time, whatever the variation in weather conditions. These results, and the consideration of the researches of other workers. lead Professor Inamdar to the view that growth is to be regarded

as an integrated summation of all the metabolic reactions, these reactions being subject to a process of auto-regulation, the object of which is to produce a total maximum growth, during equivalent physiological times in the life-history of the organism. Here the author has perhaps taken a bold line and the teleological nature of his view is perhaps scarcely in accordance with the conceptions current in modern scientific philosophy. But, as he points out, " there is a purpose which we cannot ignore and we are the happier if we can explain this purpose as a necessary consequence of antecedents." To many workers in biology the questions discussed and the problems raised in this paper will appear to be closely paralleled in the work of Loeb on artificial parthenogenesis and fertilization. The fact that it is now possible by physico-chemical means to imitate the action of the spermatozoon on the egg indicates to us that an explanation of the mysterious results of fertilization may be found in terms of physical and chemical processes. The researches which form the subject of this paper tackle the widest and most fundamental problems of modern biology and possess a theoretical and philosophical interest, which, to the reviewer at any rate, far transcends their practical importance. As Professor Inamdar suggests however " problems in physiology have a great bearing on economic problems in agriculture," and we must look to co-operation between the Universities and Departments of Agriculture for the furtherance of such fundamental researches and the application of such practical results as may accrue from them. [F. J. F. S.]

A Note on **Power Alcohol from Tubers and Root Crops in Great Britain,** being the third memorandum on fuel for motor transport, has been published, for the Department of Scientific and Industrial Research, by His Majesty's Stationery Office, Publicity Section, Publications Division, Westminster, London S.W.1. The price is stated to be 9*d.* net which is approximately nine annas. This publication which has been prepared by Sir Frederic Nathan, deals in detail with the possibilities of using potatoes, mangolds and Jerusalem artichokes as raw materials for the production of alcohol for power purposes.

The potato has been advocated frequently as a source of industrial and power alcohol, but it is still an open question whether the industry can be established on a sound commercial basis. Mention is often made of the manufacture of alcohol from this tuber on a large scale in Germany before the War. But the organization of the German enterprise was due not so much to its economic superiority as to the necessity of encouraging agriculture in the less fertile tracts of the country. As to the chances for the employment of potatoes as a material for distillation, it is concluded that, under the existing agricultural conditions prevailing in Great Britain and Ireland, a profitable industry cannot be established. A possible way in which the process can be worked out has, however, been suggested, namely, by co-operation between the potato grower and the distiller ; the erection of small distilleries in the centres of growing districts ; the combination of cattle rearing with potato culti-

vation so as to utilize the distillery residues for cattle feeding, and the use of the resulting manure to the land.

The mangold possesses several advantages over the potato as a raw material for the production of alcohol. It is an easier crop to grow, harvest and store, it is not so liable to disease and failure, and its carbohydrates being in the form of sugar, the process of manufacture of alcohol from it is simpler. Analysis of the distillation residue obtained at the Royal Naval Cordite Factory indicated that it should have considerable value as an ingredient in a feeding material rich in carbohydrates but poor in protein.

The Jerusalem artichoke also has some good points in its favour. It will grow in almost any soil so long as it is well-drained. It is moreover pointed out that after harvesting the crop there are usually many small tubers left in the soil which grow next spring. Thus when once properly established on a plot of land, no replanting should be necessary and the cost of cultivation is thus reduced to a minimum. Inulin and some of the complex carbohydrates present in this tuber are not fermentable with ordinary yeast There is reason to suppose, however, that inulin is fermented to some extent when present in a fermenting mixture of other carbohydrates. It is interesting to note that a pure resistant cellulose, which would be very suitable for certain purposes, can be prepared from the artichoke stalks.

This publication, which explores the further possibilities of an expansion of the supply of power alcohol, is very welcome. The existing supplies of mineral oils in the world are being used up and it is necessary to find out new sources of other liquid fuels. This fact is realized even by the Americans who possess a rich supply of mineral oils. In India there exist many products from which alcohol can be prepared. The difficulty lies not only in the industrial backwardness of the country, but also in the fact that most of these materials are in demand as foodstuffs and they cannot therefore be obtained at a price cheap enough for the production of power alcohol. [J. S.]

NEW BOOKS

On Agriculture and Allied Subjects

1. Crop Production and Soil Management, by J. F. Cox. (London : Chapman and Hall.) Price, 13*s*. 6*d*.
2. Genetics in Plant and Animal Improvement, by D. F. Jones. Pp. v+568 ; 220 figures. (London : Chapman and Hall.) Price, 20*s*. net.
3. Animal Breeding, by L. M. Winters. Pp. x+309 ; 65 figures. (London : Chapman and Hall.) Price, 13*s*. 6*d*. net.
4. Farm Life Abroad : Field Letters from Germany, Denmark and France, by E. C. Branson, Pp. ix+303. (London : Oxford University Press.) Price, 9*s*. net.
5. Practical Butter and Cheese Making, by L. J. Lord. (London : Ernest Benn & Co.) Price, 10*s*. 6*d*. net.
6. Report of the Proceedings of the Imperial Botanical Conference, 1924, edited by F. T. Brooks. Pp. xv+390. (Cambridge : At the University Press.) Price, 15*s*. net.

The following publications have been issued by the Imperial Department of Agriculture since our last issue

Memoirs.

1. The Phosphatic Nodules of Trichinopoly and the availability of Flour Phosphate as a Manure for Paddy, by Rao Sahib M. R. Ramaswami Sivan, B.A., Dip. Agri. (Chemical Series, Vol. VII, No. 7.) Price, R. 1-4 or 2*s*.
2. Papers on Indian Tabanidæ by P. V. Isaac, B.A., D.I.C., M.Sc., F.E.S. ; and Some Indian Species of the Dipterous Genus *Atherigona* Rondani, by J. R. Malloch (Entomological Series, Vol. VIII, Nos. 10 and 11.) Price, R. 1-8 or 2*s*.
3. The *Nim* Mealy Scale (*Pulvinaria maxima*, Green), by T. V. Ramakrishna Ayyar, B.A., F.E.S. (Entomological Series, Vol. VIII, No. 12.) Price, R. 1-4 or 2*s*.
4. Nitrogen Fixation in the Punjab, by P. E. Lander, M.A., D.Sc., A.I.C., and Barkat Ali, L.Ag. (Bacteriological Series, Vol. II, No. 1.) Price, As. 8 or 10*d*.

Bulletins.

5. Bud and Boll Shedding in Cotton, by G. R. Hilson, B.Sc., V. Ramanatha Ayyar, L.Ag., and R. Chokkalingani Pillai, L.Ag. (Pusa Bulletin No 156.) Price, As. 14 or 1*s*. 6*d*.
6. A New Fodder (Silood *Shisham* Leaves) for Dairy Cows, by P. E. Lander, M.A., D.Sc., A.I.C., and Lal Chand Dharmani, L.Ag. (Pusa Bulletin No. 158.) Price, As. 6 or 8*d*.

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EDITORIAL

COTTON LEGISLATION.

DESPITE the oft quoted half truth that people cannot be made honest by Act of Parliament, most countries have found it necessary to pass legislation to prevent, or at any rate discourage, the adulteration of important commodities. In most advanced countries Fruits and Drugs Acts and Fertilizer Acts are in force. Every cotton-growing country of importance has found it necessary to provide in some way legislative control to prevent the adulteration of cotton. The more advanced the country, the less is direct official action depended on, more reliance being placed on measures which utilize commercial organizations to secure the object in view. In America much has been done by warehouse laws. In Egypt and the Sudan there is a considerable measure of State control over cotton seed and ginneries, and decrees are in force which make the mixing of cotton an offence. In the various British Colonies measures differing in detail, according to local circumstances, have been found necessary in most cases. In India it has been found essential to deal by legislation with certain of the grosser forms of fraud. The justification for such legislation lies in the fact that abuses, which bring a small profit to a relatively small and unscrupulous section of the community cause economic loss to the country as a whole and particularly to the cotton grower.

Many years ago an attempt was made to deal with such abuses by the Cotton Frauds Act. This was a failure, because it depended entirely on official action involving the maintenance of a large inspecting staff. The two measures which the Central Cotton Committee has promoted and which have now become law, *viz.*, the Cotton Transport Act and the Cotton Ginning and Pressing Factories Act, have been made possible because the interests of the grower, consumer and responsible merchant are identical, and require that cotton should reach the mill in as nearly as possible the condition in which it is grown. There is no gain to the cotton grower, if, after producing the superior varieties for which consumers are willing to pay higher prices, the character of the produce is entirely changed owing to its being mixed with that of inferior varieties before it reaches the mill. Fortunately all responsible sections of the cotton trade are as opposed to fraudulent mixing and substitution as those who represent the grower. The Cotton Ginning and Pressing Factories Act which has recently become law does not attempt to deal with mixing, false packing and other frauds by declaring them to be criminal offences, but establishes a system of marking and recording which enables every bale of cotton to be traced back to its source. This places trade in a position to protect itself against abuses; in other words, the control of the trade by the trade is provided for. The opportunity has been taken also of providing for certain compulsory statistical returns

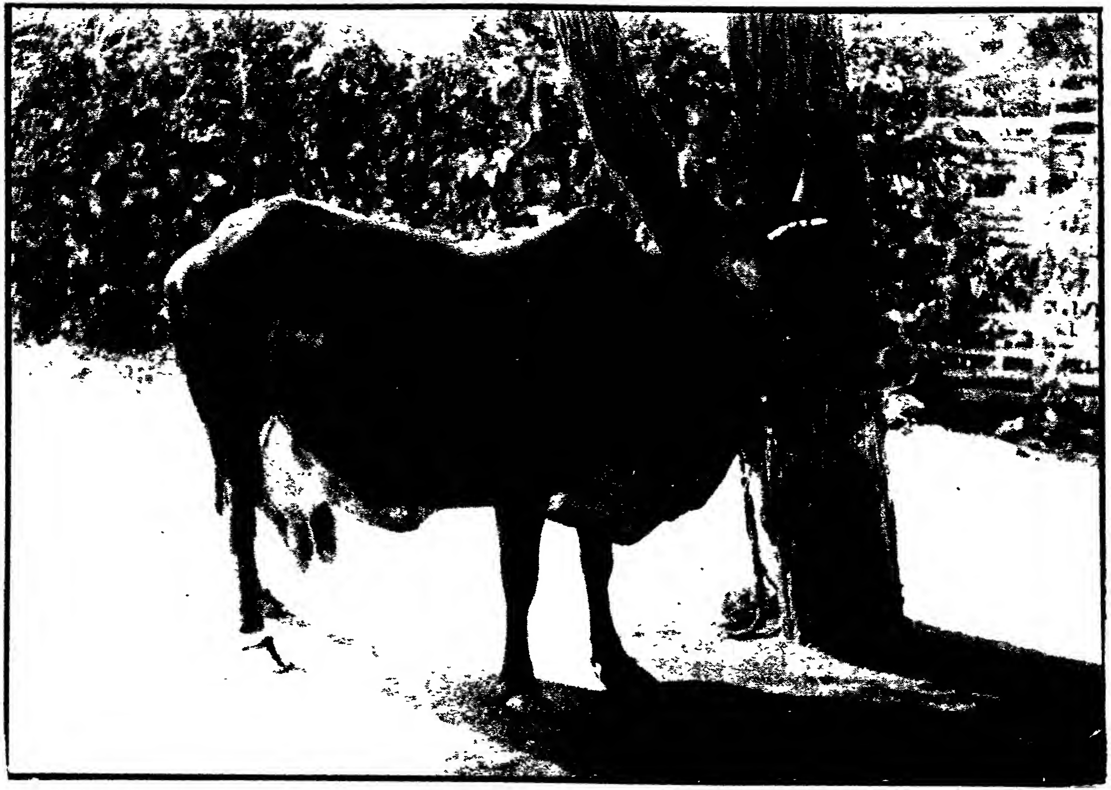
which will supply a new and independent basis for the checking of crop forecasts, and for giving the world's consumers of Indian cotton accurate knowledge regarding the progress of the crop. The necessity for this reform has been urged for many years.

The Cotton Transport Act enables a Local Government, with the consent of its Legislative Council, to declare any specified area to be a protected tract, and to forbid the importation of cotton into it either by rail, river, road or sea. It is obvious that within certain limits a considerable illegitimate profit can be made by the middlemen by importing inferior cotton into a tract where a superior cotton is grown, mixing it with the superior cotton and selling the mixture as the produce of the superior tract. Such frauds are not easily detected until they have grown to such an extent that the reputation of the whole of the cotton of the tract has been prejudiced. Outstanding examples in the past of the mischief caused in this way were the adulteration of Surat cotton with short stapled Broach or even shorter stapled Khandesh; the deliberate mixing of short stapled cottons and even mill waste with the long staple cotton of the Kumpta-Dharwar area; the adulteration of Cambodia cotton in Madras with inferior varieties from the neighbouring districts and even with inferior cotton brought hundreds of miles by rail. The Cotton Transport Act has been in force in the stapled cotton-growing areas of Bombay for nearly two years, and abundant evidence has been collected, both from trade sources and mills in Bombay, and by local enquiry as to the higher prices now received by growers. It is understood that the application of the Act to the three most important cotton areas of the Madras Presidency will shortly be effected.

From the point of view of the Agricultural Department the value of the Cotton Transport Act lies in the fact that it removes one of the greatest obstacles to the introduction of improved strains of cotton over large compact areas. To secure the full benefit of the Act it is essential that the zones chosen for protection should correspond with the department's policy in regard to seed distribution, and conversely that once a decision has been reached as to what zones are to be protected the seed distribution policy should be arranged accordingly. Very small zones should be carefully avoided.

The Cotton Ginning and Pressing Factories Act is a necessary corollary to the Cotton Transport Act. Differences in soil or irrigation facilities frequently make it difficult to standardize a single variety over a wide area, and where two different types of cotton are grown in the same zone the protection which can be obtained from the Cotton Transport Act is limited. Contrary to the common belief, careful enquiry has shown that it is not the cotton grower who is mainly responsible for the mixing of varieties. Many instances have been noticed in which though the growers brought the different varieties to market separately, they were fraudulently mixed later in ginning factories or cotton presses. While the recent Act will not *prevent* mixing in gins and presses it will render it less profitable, since it will always be possible to trace the offending press-owner or ginner and the original owner of the ginned cotton.

PLATE XXII.



RED SCINDI COW PURCHASED IN KARACHI IN 1894 BY THE LATE DR. HADJI FOR LORD HARRIS, GOVERNOR OF BOMBAY. GAVE 42 LB. MILK PER DIEM AT DATE OF PURCHASE.

ORIGINAL ARTICLES

BREEDS OF INDIAN CATTLE.

I. THE SCINDI BREED.

BY

W. SMITH,

Imperial Dairy Expert.

THE now well-known breed of cattle from the south-western part of Sind has in the past been described by some local writers and by cattle users in the Karachi District as the Karachi breed, but it is more generally known as the Scindi breed and it is by that title we prefer to describe it. These cattle are, however, by no means found all over the province of Sind. They are confined to the Karachi District as far north as Hyderabad, as far east as the river Indus, and their natural habitat extends westwards well into the Indian State of Las-Bela. Very little notice of this very fine breed of dual-purpose Indian cattle seems to have been taken by writers on dairy breeds. Messrs. Meagher and Vaughan, in their "Dairy Farming in India" published in 1904, dismiss this breed with a couple of lines in one of which they indicate that a photo of a Scindi cow produced in the volume is not a good one. In this they are quite correct. Isa Tweed in his "Cow Keeping in India" (1891 edition) makes no mention of the breed, and in his "Manual of Indian Dairying" published in 1923, Mr. Ghare of Cawnpore devotes but a few sentences to the Scindi cow. This is all the more remarkable, as it is certain that at the present time the Scindi is one of the purest and most distinct of Indian breeds of cattle; it is moreover the only breed of commercially profitable dairy cattle in this country, outside of buffaloes, which can be purchased in large numbers. Then again, in its own district at any rate, it is one of the very best examples the country produces of the dual-purpose animal; in that, in the breeding tracts the females are all used for milk production, and one has only to observe the hundreds, nay thousands, of Scindi bullocks engaged in the cartage traffic of the rapidly growing port of Karachi to realize how useful the male of this breed is for draught purposes.

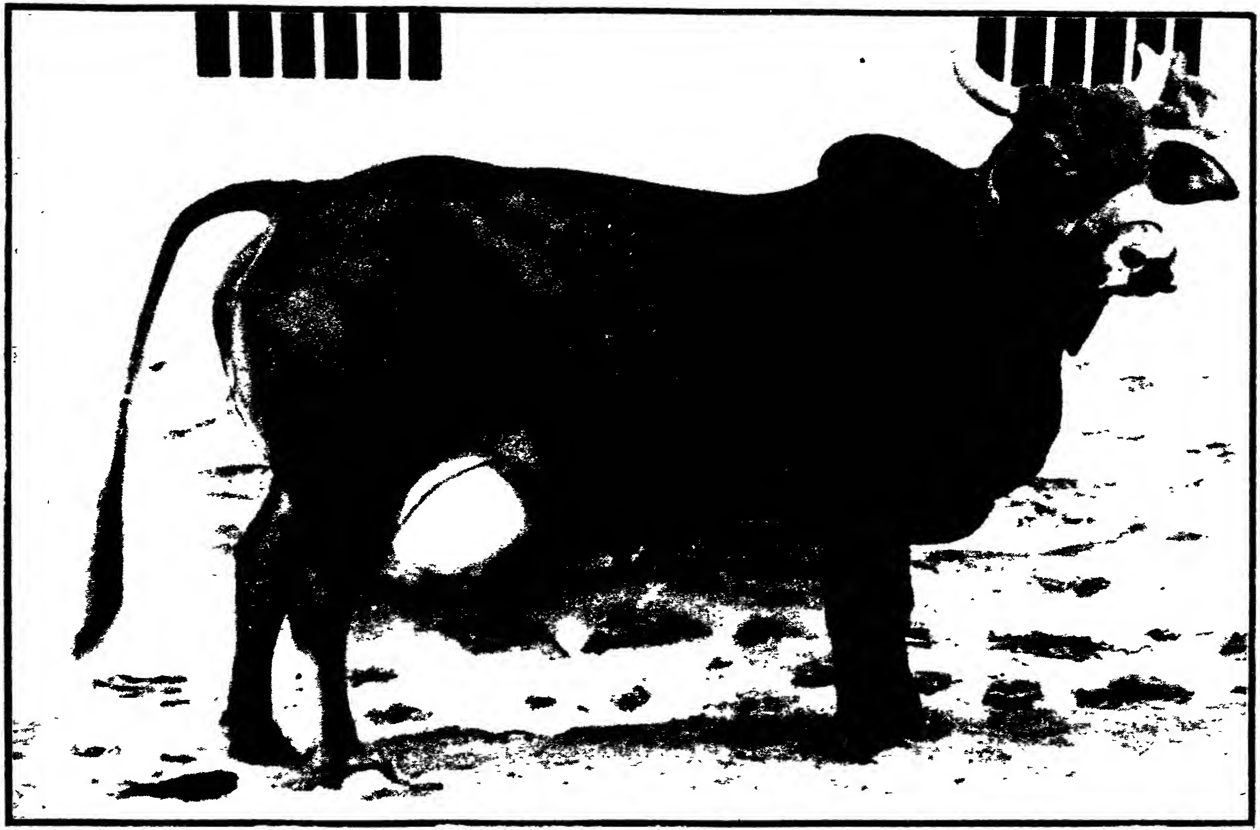
These cattle are invariably red in colour with, in some cases, white markings on the udder or hinder parts of the belly. The most common colour and that recognized

by such authorities as Mr. G. S. Henderson, Imperial Agriculturist to the Government of India, who spent many years in Sind, and the present Live-stock Expert to the Government of Bombay, as the correct colour of the breed, is a fine dark red; but variations from a dun yellow to almost dark brown are found. The bulls of this breed, as is usual in such cases, run to a much darker red than either the cows or bullocks, some being almost black when full grown. Grey or white animals, although they may approach to the breed type in shape and other characteristics, are not true Scindi cattle; the grey colour clearly indicates an admixture of some of the many white or grey breeds found in the country adjacent to the tracts producing Scindi cattle. The Scindi cattle, either male or female, are of medium size and weight; in shape they are compact and symmetrical with the true wedge shape in the case of the female. The head is short, the forehead broad and generally slightly protruding. The eyes are clear and well set apart; the muzzle is broad, and the neck is generally short and fairly thick. The horns vary considerably in shape and type, but the most common form is a short thick type. The Scindi is broad in the chest, and deep in the rib, and has a fine slack skin and rounded light hind quarters. Like all Indian breeds of cattle, the hind quarters are too narrow for really heavy milk production; in the development of this breed by selective breeding, it is certain that the widening of the hind quarters and the enlargement of the udder backwards would greatly improve the type. The tail is long and fine with a long black switch, and the udder is generally well formed with large well set teats. The typical udder of the breed is faulty, in that although it runs well forward it does not come far enough back between the hind legs for a perfect milch cow. Milk veins are not too prominent, and in the male the rudimentary teats are well formed. The escutcheon is generally pronounced, but, owing to the above faulty udder development, it does not, in its markings, enclose sufficient area. In the bulls the sheath is loose and pendulous to a moderate degree, and the dewlap in both sexes is voluminous and silky to the touch. The Scindi has fine bone, fine glossy hair, and when in prime c ndition is one of the most beautiful types of cattle in this country.

The Scindi cow is particularly placid and docile, and moves with easy grace; in fact, her superb carriage, fine poise of the head, and general alertness combine to produce a degree of distinction not found in any other type of Indian cow. Although the breed is remarkable for evenness of temper and docility of character. neither cows nor bullocks are wanting in spirit. The Scindi bullock, although not so swift or agile in his movements as that of certain other breeds, is a steady worker, and is not given to lying down under a heavy load like the male of the Sahiwal breed.

The photograph (Plate XXV, fig. 2) shows two Scindi bullocks bought in Karachi market when one month old and raised at the Imperial Institute of Animal Husbandry and Dairying, Bangalore. These animals have done seven years of real hard work for 365 days each year. They have not been sick nor sorry and are strong ready workers of a lasting type. One of these bullocks weighed 870 lb. and the

PLATE XXIII.



RED SCINDI COW "GANGA" PURCHASED IN KARACHI IN 1914 FOR HIS EXCELLENCY LORD WILLINGDON, GOVERNOR OF BOMBAY.

Red Scindi Cow "Iris," age 7½ years Property of Willingdon Cattle Farm. Yield, 7,749 lb. of milk in 278 days; in addition to which she gave one month's milk before recording commenced.

Red Scindi Bull "Kalmast" bred by the Willingdon Cattle Farm. Property of His Highness Mir Ali Nawaz Khan of Khairpur State.

other 885 lb. when photographed. The weight of a typical full-grown Scindi bull at the Bangalore farm is 915 lb., and the average weight of 6 typical Scindi cows between 5 and 8 years of age was found to be 730 lb.

Reference has already been made to the purity of the breed, and in this connection it is remarkable that Scindi bulls purchased by the writer in the open market within the last twenty years from ordinary illiterate breeders have invariably produced a good class of milch cow, and without exception have, when mated with dams of other breeds, stamped their characteristics on their offspring. The purity of the breed is largely due to the isolated nature of the district in which the cattle have been bred for centuries. There are no railways and no roads west of Karachi.

In the book "Manual of Indian Dairying" before referred to, the author states that the Scindi cow does not seem to do well when removed far from its own locality, but with this view the writer cannot agree. For many years there has been a regular export trade in Scindi cows from Karachi to Ceylon, the Malay States, and Sumatra. The writer has met in Karachi buyers from the Government of Sumatra who had come there to purchase Scindi cattle, and cattle have actually been purchased in Scind by the Imperial Dairy Expert and shipped to Mesopotamia, Formosa, Burma, Baluchistan, the North-West Frontier Province, Mauritius, Borneo, and Ceylon. No breed of cattle accustomed for centuries to the hot dry climate of Sind could be expected to do as well in a damp moist climate like Rangoon as they would in their own country, but on the whole the Scindi cow has proved herself as adaptable as any other Indian breed. In fact, I know of no other Indian breed of cattle which could be relied upon to repeat the performances of the Scindi as a milk-producer in places so far apart as Mosul and Mandalay. The figures given later regarding the milk yields of this breed are the best proof of this which can be put forward. During the Great War the writer purchased and shipped to Mesopotamia for the military farms there some 3,500 Scindi cows in milk. Reporting on these cattle, the Director of Agriculture, Mesopotamia, in his report for 1919 says :—" All the animals have done well in Mesopotamia * * * * . The average milk yield of the cows worked out at 9·5 lb. per head per diem, etc., etc."

For two years large numbers of cows of this breed continued to be purchased for Mesopotamia and at no time during this period was there any scarcity of good young animals in milk. To-day any reasonable number of a good class of Scindi cows is obtainable in Karachi. The supply keeps pace with the demand. Ordinarily breeders make it a business to breed and rear cows and a limited number of bulls for the export trade.

Although the Scindi breed provides in its own country a very good example of dual-purpose qualities, it is as a milch cow that it is known throughout the East, and in this connection the most important factor is the yield of milk which the breed will give both in regard to quantity and quality, and no apology is therefore made for giving the following authenticated records of yields of known herds of Scindi cows in different parts of the East. These figures not only indicate the capacity of the

breed as milkers, but they substantiate the writer's contention that the Scindi breed can readily adapt itself to altered conditions of life :—

(a) *Average yield of the Scindi cows at the Agricultural College, Poona, for the past five years.*

Year	Number of cows in the herd	Average annual milk yield per animal in lb.
1920-21	17	2,027·2
1921-22	30	2,441
1922-23	34·5	2,454
1923-24	41	2,427
1924-25	38	2,961

(b) *Test of butter fat percentage of eight Scindi cows lately made at the Agricultural College, Poona.*

Serial No. of animals	Period after calving in months	Average fat of four consecutive tests
1	$4\frac{1}{2}$	4·20
2	$3\frac{1}{2}$	4·69
3	$2\frac{1}{2}$	5·70
4	$4\frac{1}{2}$	5·30
5	$2\frac{1}{2}$	5·25
6	$2\frac{1}{2}$	4·81
7	$2\frac{1}{2}$	5·81
8	$2\frac{1}{2}$	5·03

(c) *Yield of cow sent to Mr. Stephens, Rangoon.*

1st Lactation 6,100 lb. in 16 months.

2nd „ 4,000 lb. in 6 „ —still milking.

(*d*) ***Yield of eight average class Scindi cows at Willingdon Cattle Farm, Karachi (Government of Bombay).***

Name and number of animals	1st Lactation		2nd Lactation	
	No. of days in milk	Yield lb.	No. of days in milk	Yield lb.
Matari, No. 22	373	5,647	366	5,158
Machaji, No. 24	393	5,152	224	2,392
Sugni, No. 32	343	4,944	198	4,073
Sonni, No. 18	312	4,992	236	4,140
Chaugi, No. 26	344	4,759	202	2,377
Bhoor, No. 47	241	3,423	157	1,719
Karachi, No. 3	335	3,421	303	3,727
Moomal, No. 25	331	3,070	289	3,792

(*e*) ***Yield of Scindi herd at Agricultural College, Mandalay.***

Number of cow	1st Lactation		2nd Lactation	
	No. of days in milk	Yield lb.	No. of days in milk	Yield lb.
1	278	3,103	195	2,166
2	336	3,087	76	212
3	218	2,029	238	2,068
4	330	3,080	259	2,832
5	255	2,557	378	4,126
6	269	2,007	455	3,977
7	300	2,155	292	2,249
8	286	3,724	425	4,020

Note.—Above cows were purchased at Karachi in the open market.

(*f*) *Yield of selected Scindi cows at Military Dairy Farm, Mhow, C. I.*

Number of cow	No. of days in milk	Yield lb.	No. of days dry	Average during lactation	Average 1st to last calving
				lb.	lb.
234	376	3,841	24	10·2	7·8
972	337	4,885	64	14·5	10·8
946	332	4,060	218	12·2	7·4
	224	4,648	155	20·7	9·4
	268	5,263	123	19·6	10·5
	211	4,243	119	20·1	11·0
180	289	3,702	132	12·9	8·8
	289	3,767	99	13·1	9·2
	254	3,046	130	11·9	8·9
486	363	4,227	109	11·6	..
	311	4,869	243	15·6	..
	310	3,944	210	12·7	..
D83	455	4,000	17	8·8	8·7
	354	2,823	28	7·9	8·0
	354	3,000	9	8·4	8·2
	235	3,159	213	13·4	7·8

(*g*) *Yield of Scindi cows at the Imperial Institute of Animal Husbandry and Dairying, Bangalore.*

Period	Daily average over herd	Yearly average over herd	Daily average No. of cows in herd
	lb.	lb.	
1922-23	7·65	2,792	21
1923-24	8·05	2,938	16
1924-25	8·93	3,259	26

NOTE.—Above cows were purchased at Karachi in the open market.

(*h*) ***Statement of the lactation yields, etc., of eight average Scindi cows at the Palace Dairy, Mysore.***

Cow No.	Date of calving	Date of going dry	Days in Milk	Yield lb.	Average daily yield (lb.) for lactation	Dry days
44	10-3-16 . .	17-2-17 . .	343	3,845	11·2	223
	29-9-17 . .	30-6-18 . .	273	4,553	16·6	236
	21-2-19 . .	31-1-20 . .	343	4,212	12·2	145
	25-6-20 . .	23-8-20 . .	58	489	5·4	298
	18-6-21 . .	12-2-22 . .	258	2,662	10·3	84
	7-5-22 . .	8-10-22 . .	154	1,295	8·4	156
	13-3-23 . .	8-1-24 . .	301	2,458	8·1	315
	18-11-24 . .	in milk				
96	9-9-19 . .	2-5-20 . .	234	2,611	11·1	209
	27-11-20 . .	31-3-21 . .	123	1,276	10·1	278
	3-1-22 . .	26-11-22 . .	327	3,858	11·1	39
	4-1-23 . .	12-10-23 . .	290	3,498	12·0	75
	26-12-23 . .	22-9-24 . .	270	2,767	10 2	89
	20-12-24 . .	in milk				
112	1-5-17 . .	23-11-17 . .	205	964	4·7	85
	16-12-18 . .	7-9-18 . .	202	867	4·3	120
	4-1-19 . .	31-12-19 . .	361	3,628	10·0	19
	19-1-20 . .	20-8-20 . .	213	2,404	11·2	135
	3-1-21 . .	13-7-21 . .	192	2,153	11·2	118
	9-11-21 . .	7-3-23 . .	494	4,828	9·7	140
	5-8-23 . .	29-6-24 . .	329	4,442	10·4	64
	1-9-24 . .	in milk				

(*h*) *Statement of the lactation yields, etc., of eight average Scindi cows at the Palace Dairy, Mysore*—contd.

Cow No.	Date of calving	Date of going dry	Days in milk	Yield lb.	Average daily yield (lb.) for lactation	Dry days
722	23-9-16 . .	28-7-17 . .	308	3,563	11·5	241
	26-4-18 . .	30-7-19 . .	457	5,531	12·1	102
	11-11-19 . .	14-12-20 . .	394	5,003	12·7	122
	15-4-21 . .	13-2-22 . .	304	3,760	12·3	113
	6-6-22 . .	22-7-23 . .	411	3,627	8·8	81
	11-10-23 . .	8-6-24 . .	241	2,142	8·8	124
	10-10-24 . .	in milk				
		Dry cows.				
5	Oct. 20 . .	20-7-21 . .	246	2,036	8·2	83
	12-10-21 . .	14-12-21 . .	63	399	6·2	415
	2-2-23 . .	15-2-24 . .	317	4,486	14·1	50
	5-4-24 . .	30-9-24 . .	178	1,780	10·0	...
30	Oct. 20 . .	27-5-21 . .	188	612	3·2	133
	7-10-21 . .	30-7-22 . .	296	2,466	8·2	265
	21-4-23 . .	8-3-24 . .	322	3,127	9·6	77
	24-5-24 . .	8-3-25 . .	288	2,643	9·1	..
102	June 10 . .	24-11-10 . .	139	1,318	9·4	421
	29-1-12 . .	11-11-12 . .	286	2,513	8·8	219
	17-6-13 . .	3-8-14 . .	413	3,105	7·8	141
	25-12-14 . .	28-10-15 . .	303	2,994	9·8	216
	4-6-16 . .	21-12-17 . .	257	2,837	11·0	154
	26-7-17 . .	17-8-18 . .	399	3,845	9·4	138
	21-1-19 . .	26-10-19 . .	276	3,183	11·6	71
	5-1-20 . .	8-12-20 . .	303	3,384	11·0	79

(h) Statem nt of the lactation yie ds, etc., of eight average Scindi cows at the Palace Dairy, Mysore—concld.

Cow No.	Date of calving	Date of going dry	Days in milk	Yield lb.	Average daily yield (lb.) for lactation	Dry days
		Dry cows—concld.				
	25-2-21 . .	3-1-22 . .	281	3,138	11·0	148
	30-4-22 . .	8-4-23 . .	343	3,293	9·6	101
	18-7-23 . .	15-5-24 . .	302	2,043	6·7	106
	30-8-24 . .	1-2-25 . .	155	987	6·3	...
142	30-5-17 . .	22 12-17 . .	205	1,828	9·0	321
	7-11-19 . .	10-8-19 . .	276	2,647	9·6	146
	31-1-20 . .	30-9-20 . .	240	2,578	10·4	169
	18-4-21 . .	4-2-22 . .	292	4,128	14·1	71
	16-4-22 . .	27-10-22 . .	195	2,867	14 8	207
	23-5-23 . .	22-11-23 . .	183	1,946	10·6	137
	7-5-24 . .	22-11-24 . .	199	2,699	13 5	..

NOTE.—These cows were purchased at Karachi in the open market.

(i) Yield of Scindi cows at the Agricultural College Dairy, Coimbatore.

Number of cow	Date of calving	Length of lactation period in days	Milk yield lb.	Average daily yield (lb.) during lactation	REMARKS
24	March 21 .	417	6,651·7	13·3	
	22-8-22 .	221	3,840·7	17·5	
	5-3-24 .	128	2,182·0	17·0	Went dry due to mammitis.
25	March 21 .	373	6,767·0	18·0	
	6-7-23 .	253	4,564·0	18·0	
	8-2-25 .	131	2,992·3	22·7	In milk.

(*i*) *Yield of Scindi cows at the Agricultural College Dairy, Coimbatore*—concld.

Number of cow	Date of calving	Length of lactation period in days	Milk yield lb.	Average daily yield (lb.) during lactation	REMARKS
26	March 21 .	298	2,119·0	7·0	
	5-9-22 .	339	3,500·0	10·2	
	22-5-24 .	393	4,712·3	12·0	In milk.
27	March 21 .	162	1,504·0	9·2	
	9-1-22 .	141	1,218·0	9·0	
	26-12-22 .	229	2,384·0	10·4	
	8-2-24 .	372	3,462·0	9·3	
	8-5-25 .	42	808·0	18·5	In milk.
28	Sept. 21 .	76	470·0	6·2	Record from date of arrival.
	6-6-24 .	351	3,857·0	11·0	
29	Sept. 21 .	72	303·7	4·2	Record from date of arrival.
	11-10-22 .	283	3,481 0	12·3	
	27-7-24 .	327	4,349·7	13·7	In milk.
30	Oct. 21 .	63	278·7	4·3	Record from date of arrival.
	21-9-24 .	271	2,769·3	10·6	In milk.
33	Sept. 21 .	120	680·0	5·7	
	20-2-23 .	308	3,868·0	12·6	
	30-4-24 .	306	3,601·0	11·7	
34	17-5-24 .	293	2,576·0	9·0	
35	9-5-24 .	68	359·0	5·3	
	16-4-25 .	64	1,115·3	18·0	In milk.
36	21-3-25 .	50	238·3	4·8	

NOTE.—Most of these cows were purchased at Karachi in the open market,

(j) ***Recent tests of fat and solids not fat of individual Scindi cows at the Imperial Institute of Animal Husbandry and Dairying, Bangalore.***

Cow's number	No. of days in milk	Morning			Evening		
		S. G.	Fats	Total solids	S. G.	Fats	Total solids
19TH MARCH 1925							
No. 2 . .	54	1030	3·4	11·62	1031	4·2	12·9
No. 3 . .	189	1030	5·3	14·0	1030	6·5	15·44
No. 4 . .	118	1032	4·4	13·4	1030	4·6	13·16
No. 13 . .	115	1029	4·4	12·67	1030	5·0	13·64
No. 14 . .	134	1032	4·6	13·66	1030	5·0	13·64
No. 19 . .	40	1030	5·0	13·64	1030	5·4	14·12
No. 20 . .	67	1032	3·8	12·6	1032	4·0	12·94
No. 899 . .	216	1031	4·6	13·41	1031	6·2	15·33
20TH MARCH 1925							
No. 2 . .	55	1032	3·3	12·1	1031	4·6	13·41
No. 3 . .	190	1030	5·1	13·72	1030	5·8	14·6
No. 4 . .	119	1034	4·2	13·68	1029	4·6	12·91
No. 13 . .	116	1030	4·3	12·8	1030	4·9	13·52
No. 14 . .	135	1030	4·5	13·01	1030	4·8	13·4
No. 19 . .	41	1030	4·8	13·4	1030	4·8	13·4
No. 20 . .	68	1031	3·9	12·57	1031	4·0	12·69
No 899 . .	217	1030	4·8	13·4	1029	6·0	14·59
21ST MARCH 1925							
No. 2 . .	56	1032	3·0	11·74	1031	4·7	13·53
No. 3 .	191	1030	4·8	13·4	1028	6·5	14·94
No 4 . .	120	1031	5·2	14·13	1030	5·5	14·24
No. 13 .	117	1032	3·0	11·74	1029	5·0	13·39
No 14 . .	136	1031	4·4	13·17	1030	5·1	13·76
No. 19 . .	42	1030	3·6	11·96	1030	4·7	13·28
No. 20 . .	69	1032	4·0	12·94	1031	4·3	13·05
No. 899 .	218	1030	5·2	13·88	1029	6·7	15·43
22ND MARCH 1925							
No. 2 . .	57	1032	3·0	11·74	1030	4·4	12·92
No. 3 . .	192	1030	4·5	13·04	1030	5·1	13·76
No. 4 . .	121	1030	4·6	13·16	1030	4·8	13·4
No. 13 . .	118	1030	4·2	12·83	1029	5·1	13·51
No. 14 . .	137	1030	4·3	12·8	1029	4·8	13·15
No. 19 . .	43	1031	4·0	12·69	1029	4·6	12·91
No. 20 . .	70	1031	4·2	12·83	1030	4·5	13·04
No. 899 . .	219	1029	5·0	13·39	1029	6·0	14·59

(*j*) *Recent tests of fat and solids not fat of individual Scindi cows at the Imperial Institute of Animal Husbandry and Dairying, Bangalore*—contd.

Cow's number	No. of days in milk	Morning			Evening		
		S. G.	Fats	Total solids	S. G.	Fats.	Total solids
23rd March 1925							
No. 2 . .	58	1030	3·0	11·24	1031	4·8	13·65
No. 3 . .	193	1029	5·0	13·39	1028	6·2	14·58
No. 4 . .	122	1030	4·0	12·44	1030	4·3	12·8
No. 13 . .	119	1030	4·5	13·04	1030	4·9	13·52
No. 14 . .	138	1030	4·5	13 04	1029	5·0	13·39
No. 19 . .	44	1031	3·8	12·45	1030	4·9	13·52
No. 20 . .	71	1030	3·5	11·84	1030	4·6	13·16
No. 899 . .	220	1029	5·6	14·11	1028	6·6	15·06
24th March 1925							
No. 2 . .	59	1029	3·4	11·47	1030	4·6	13·16
No. 3 . .	194	1029	3·8	11·95	1030	5·0	13 64
No. 4 . .	123	1030	4·0	12·44	1030	4·5	13 04
No. 13 . .	120	1029	4 0	12 19	1030	4·5	13·04
No. 14 . .	139	1031	4 3	13 05	1031	4·8	13·05
No. 19 . .	45	1030	3·2	11·18	1029	4·6	12·91
No. 20 . .	72	1031	4·0	12·69	1029	4 6	12·91
No. 899 . .	221	1029	5·6	14·11	1030	6·5	15·45
25th March 1925							
No. 2 . .	60	1032·5	4·8	14·02	1031	6·1	15·21
No. 3 . .	195	1029	4·1	12·31	1031·2	5·8	14·97
No. 4 . .	124	1032·5	3 8	12·82	1031	6·0	15·09
No. 13 . .	121	1031·5	4·8	13·77	1030	5·2	13·88
No. 14 . .	140	1032	3·8	12·7	1030	5·6	14·36
No. 19 . .	46	1029	4·9	13·27	1030	5·1	13·76
No. 20 . .	73	1032·5	3·6	12·58	1031	5·1	14·01
No. 899 . .	222	1031	5·6	14·61	1032	6·7	16·18
26th March 1925							
No. 2 . .	61	1030 5	4·4	13·04	1029·5	5·8	14·47
No. 3 . .	196	1029·5	4·5	12·91	1030	6·1	14·96
No. 4 . .	125	1031 5	4·3	13·07	1030	5·4	14·12
No. 13 . .	122	1030·5	4·3	12·82	1030	4·9	13·52
No. 14 . .	141	1031·5	3·5	12·21	1029	5·0	13·39
No. 19 . .	47	1030·5	3·5	11·46	1030	5·0	13·64
No. 20 . .	74	1031·5	3·8	12·57	1029	4·8	13·15
No. 899 . .	223	1032·5	4·8	14·02	1028·5	6·8	15·42

(j) Recent tests of fat and solids not fat of individual Scindi cows at the Imperial Institute of Animal Husbandry and Dairying, Bangalore—contd.

Cow's number	No. of days in milk	Morning			Evening		
		S. G.	Fats	Total solids	S. G.	Fats	Total solids
27th March 1925							
No. 2 . .	62	1030	4·8	13·4	1030	4·4	12·92
No. 3 . .	197	1030	4·9	13·52	1030	5 0	13 64
No. 4 . .	126	1033	4·5	13·79	1031	6 0	15 09
No. 13 . .	123	1031	4·8	13·65	1029	5·0	13·39
No. 14 . .	142	1033	3·6	12·71	1029	5·1	13·51
No. 19 . .	48	1030	3·3	11·6	1030	4·9	13·52
No. 20 . .	75	1031	3·6	12·21	1030	4·5	13·04
No. 899 . .	224	1032	4·5	13·54	1029	6·0	14·59
28th March 1925							
No. 2 . .	63	1029	4 4	12·64	1031	5·2	14·13
No. 3 . .	198	1029	4·4	12·64	1031·5	5·4	14·49
No. 4 . .	127	1030	4 3	12·8	1030	5·2	13 88
No. 13 . .	124	1030	4 5	13·04	1029·5	5·1	13·61
No. 14 . .	143	1029	3 5	11·59	1030	5·6	14·36
No. 19 . .	49	1029	3·1	11·11	1030	5 1	14 76
No. 20 . .	76	1030	4·0	12·44	1029	5 0	13·39
No. 899 . .	225	1030	4·8	13·4	1031	6·5	15·69
29th March 1925							
No. 2 . .	64	1030	3·8	12·2	1030	5·5	14·24
No. 3 . .	199	1028	3·9	11·82	1028	5·6	13·86
No. 4 . .	128	1031	4·2	12·93	1030	5·4	12·12
No. 13 . .	125	1028	4·8	12·9	1029	5·0	13·39
No. 14 . .	144	1029	4·6	12·91	1030	5·9	14·72
No. 19 . .	50	1028	4·5	12·54	1029	4·7	13·03
No. 20 . .	77	1032	3·4	12·22	1029	5·2	13·63
No. 899 . .	226	1029	4·7	13·03	1030	5·1	13·76
30th March 1925							
No. 2 . .	65	1029	3·6	11·71	1030	4·6	13·16
No. 3 . .	200	1029·5	5·3	13·87	1029	5·6	14·11
No. 4 . .	129	1029·5	4·4	12·79	1030	5·3	14 0
No. 13 . .	126	1030	4·3	12·8	1030·5	4·8	13·52
No. 14 . .	145	1030	3·7	12·08	1030	4 8	13·4
No. 19 . .	51	1029	3·3	11·35	1030	4·9	13·52
No. 20 . .	78	1029·5	3·8	12·07	1030	4·7	13·28
No. 899 . .	227	1030	4·8	13·4	1029	6·3	14·95

(*j*) *Recent tests of fat and solids not fat of individual Scindi cows at the Imperial Institute of Animal Husbandry and Dairying, Bangalore*—concld.

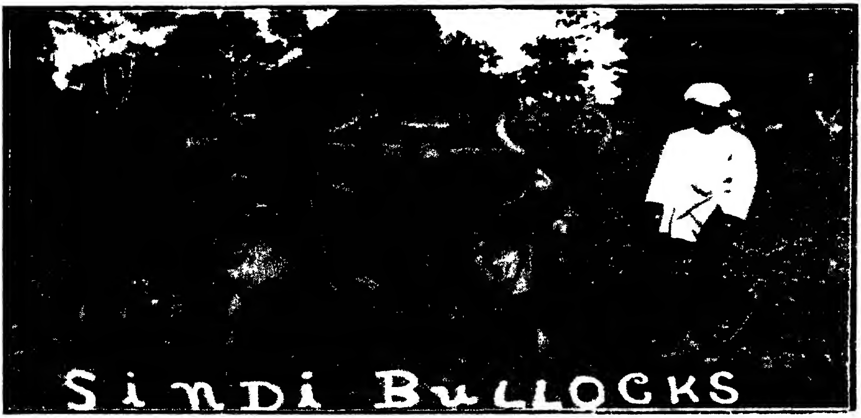
Cow's number	No. of days in milk	Morning			Evening		
		S. G.	Fats	Total solids	S. G.	Fats	Total solids
			31st March 1925				
No. 2 . .	66	1029	3·6	11·7	1030	4·6	13·13
No. 3 . .	201	1029·5	5·3	13·85	1029	5·6	14·11
No. 4 . .	130	1032	3·9	12·82	1030	5·1	13·74
No. 13 . .	127	1030·5	4·4	13·04	1030	5·2	13·88
No 14 . .	146	1032	3·8	12·7	1031	4·7	13·53
No. 19 . .	52	1030	3·6	11·96	1031	4·5	13·29
No. 20 . .	79	1032	3·3	12 1	1031·5	4·8	13·77
No. 899 . .	228	1031	5·0	13·89	1030	6·1	14·96
			1st April 1925				
No. 2 . .	67	1030 5	4·8	13·52	1030	4·7	13·28
No. 3 . .	202	1029·5	4·5	12·9	1030	5·8	14·56
No. 4 . .	131	1032·5	3·8	12·81	1030	5 3	14·0
No. 13 . .	128	1031·5	4·3	13 17	1029	5·0	13·37
No 14 . .	147	1031 5	3·8	12·54	1030	4·9	13 5
No. 19 . .	53	1030·5	3·2	11·6	1030	4·9	13 55
No. 20 . .	80	1031·5	3·9	12·68	1029	4·8	13·14
No. 899 . .	229	1030·5	4·9	13·65	1028 5	6·8	15·4

Test taken at temperature 60°F.

The foregoing figures indicate three things—(1) the quantity of milk which the Scindi cow can give under varying conditions, (2) the quality of the milk yielded by the breed, and (3) the degree of adaptability of the Scindi to varying climatic conditions when removed from their natural habitat. It does not appear to be either desirable or necessary to analyse or comment on these figures; they are authentic and speak for themselves. The milk of the Scindi cow is faintly primrose in tint, and the butter made from the milk of this breed has a distinct pale yellow colour.

The Scindi cow being of a placid temperament can easily be milked without the calf if treated in this fashion from the birth of her first calf; even in the case of older animals purchased in Sind all that is necessary to induce the cow to give her full yield is to tie the calf alongside the foreleg of the dam. It is not at any time essential with this breed to permit the calf to suckle the dam. If the cows are weaned and milked entirely without the calf, they will with proper care and management yield a calf every 13½ months on the aggregate; but when cows are milked with the calf, even although the calf is not permitted to actually suckle the dam either before or after milking, on the average one calf per fifteen to sixteen months is what can be obtained.

Scindi Cow No. 721, Bangalore Farm Gave 7,175 lb. and 7,272 lb. of milk during last two lactations.



Pair of Scindi Working Bullocks at the Imperial Institute of Animal Husbandry and Dairying, Bangalore.

HERD OF RED SCINDI COWS AT THE IMPERIAL INSTITUTE OF ANIMAL HUSBANDRY AND DAIRYING, BANGALORE.

The Scindi breed carry a considerable degree of immunity to the common cattle diseases of their country. With careful nursing they generally get over foot-and-mouth quickly and without serious loss in weight, and they are not less immune to rinderpest than most of the well-known breeds of plains cattle in India. Reared as they are in a bare desert country where they have to search diligently for their feed, they are a hardy healthy race of cattle in no way pampered in their natural breeding grounds. With careful rearing under dairy farming conditions, the heifers are ready and fit to take the bull at from 2½-3 years of age and the bulls are fit for service at three years. The judging of the age of Scindi cattle by dentition is not an easy matter in the breeding tracts in Sind, because of the great wear on the teeth of animals which graze on these hard stony regions where they literally have to dig up the roots of the grass with their teeth at the driest seasons of the year.

To sum up, the Scindi breed is to-day the foremost of milch cattle in India, and, although owing to the comparative slowness of movement of the bullock, the Scindi may not be suitable for classification as an ideal dual-purpose breed, yet it is an example of a dual-purpose type of no mean order. Not only so, but the Scindi cow is the only class of commercially profitable milch cow available in India to-day in large numbers and at reasonable rates. It is possible for a buyer to go to Karachi District and to buy at a reasonable cost, say, 500 cows within two weeks, which, if the buyer knows as much as the dealers about cow lore and cow quality, will yield on an average 2,500 lb. milk per year in almost any part of the East, if given proper living conditions. This could not be done in any other part of the Indian Empire to-day.

Measurement figures so often given in literature relative to Indian cat le have been purposely omitted from this article. No breed or type of cattle can be judged by figures of this kind. The writer has attended the great cattle shows in many countries of Europe and America where the greatest authorities on the world's breeds of cattle were judging, but he has never yet seen a recognized judge of cattle use either a tape measure or a foot rule. It is the "tout ensemble" which counts.

THE INFLUENCE OF A HIGH GRADE BULL ON A DAIRY HERD.

BY

G. S. HENDERSON, N.D.A., N.D.D.,

Imperial Agriculturist.

An interesting article on the above subject is published in the "Agricultural Journal of South Australia" of March 16th, 1925. It is pointed out how valuable are highly prepotent bulls on the milk production of a dairy herd. It is very truly stated that most breeders have had the experience of discovering the stud value of an exceptional sire after the said animal had gone beyond recall. The figures of milk yield of the progeny of different bulls from the Roseworthy Dairy Herd in South Australia show very clearly the powers which some bulls have in transmitting milking qualities to their offspring. Sufficient care and attention is seldom given to the necessity of retaining sires until it is shown that they can hand down the milking characteristics to their progeny. It does not seem to be realized among breeders that having got the desired animal its characteristics must be retained and developed in the herd by in-breeding.

With the early maturing foreign cattle it is necessary to wait a considerable time before definite results can be obtained, but with the much slower maturing Indian dairy cattle the time required is much longer. Cattle-breeding in India on modern lines, with the keeping of proper records, has only been carried out in very recent years and almost entirely by Government agencies. When it is realized that any policy in agriculture in India is very unlikely to have any considerable period of continuity owing to the continuous change of personnel in Government posts, it will be manifest that progress in cattle-breeding in this country is beset with many difficulties. Some of these difficulties in breeding operations in India are :—

1. Indian cattle are about two years later in reaching maturity than improved foreign cattle.
2. They are accustomed to suckle their calves. At Pusa it was very difficult at first to get the calves weaned at birth.
3. They do not breed so regularly as improved foreign cattle, so a big proportion of the milk herd is always a heavy charge as the cows spend so long dry.

The milking results of the progeny of two bulls have been worked out from the Pusa Dairy Herd. These are Sahiwal cattle, the original stock being brought from the Punjab. This is about the best dairy type in India, but the cows present considerable differences from the improved dairy cattle as evolved in Europe. 4,000 lb. of milk in a lactation period of ten months represents a standard fully as good as a 9,000 lb. yield of an improved foreign dairy cow.

The record of the 11 daughters of Prayagi, still in the herd, is given below. All lactations are for ten months.

TABLE I.

Showing the influence of sire Prayagi on the milk-producing qualities of his progeny.

Name and number of cow	Best lactation	Dam	Dam's best lactation	Increase or decrease in milk yield
	lb.		lb.	lb.
1. Ashrafi 211	4,670	Panji 39	4,665	+ 5
2. Chakli 203	4,317	Padmini 56	4,094	+ 223
3. Akli 231	5,046	Raseeli 132	4,812	+ 234
4. Jamali 237	4,420	Divali 77	3,827	+ 593
5. Deoki 213	5,349	Gomti 75	3,346	+ 2,003
6. Chabili 187	4,729	Rami 78	3,764	+ 965
7. Parbati 245	4,037	Rajni 76	4,867	— 830
8. Gopi 219	5,121	Foorsi 103	320	+ 4,801
9. Soonehri 248	4,223	Makhni 28	4,407	— 184
10. Kadambari 243	6,347	Jaidi 47	4,979	+ 1,368
11. Abadi 238	4,624	Durgavati 136	3,139	+ 1,485

It will be seen that the two cases of decrease in milk yield still keep the daughters' yield above 4,000 lb., which is an excellent yield for an Indian cow.

The next table shows the influence of a bad sire. Out of 10 daughters of Himmat, all except one proved to be very bad milkers even in the second lactation.

TABLE II.

Showing the influence of sire Himmat on the milk-producing qualities of his daughters.

Name and number of cow		Best lactation	Dam		Dam's best lactation	Increase or decrease
		lb.			lb.	lb.
Hanumati	399	4,848	Kaveri	133	4,786	+ 62
Himmati	348	1,728	Gomti	75	3,346	—1,618
Goli	305	410	Mootki	122	3,435	—3,025
Hasni	339	2,620	Imani	138	6,200	—3,580
Halia	393	1,619	Imani	138	6,200	—4,581
Rati	358	1,445	Dhoonki	181	3,240	—1,795
Haldi	379	3,064	Chakli	203	4,317	—1,253
Hundi	383	3,624	Kapurni	283	3,195	+ 429
Hathia	386	1,324	Radhia	279	3,520	—2,196
Hisli	353	675	Thakrani	250	3,923	—3,248

The above examples show very clearly that the influence of the sire, for good or for evil, in the dairy herd is a fundamental question.

Two sons of Prayagi were used in the Pusa Herd—Thakur and Khelawan. Thakur has shown himself to be an exceptionally prepotent sire. A few of his heifers were close on 5,000 lb. in their first lactation. His brother, however, has not given such good results. All these bulls were cleared out of the herd long before their importance was known, but in-breeding with their descendants to get as large a proportion of the required blood as possible is being carried out at present. To get bulls containing a large proportion of this blood will mean considerable time and continuity of policy which is rather too much to be hoped for under present conditions.

SOME RECENT ADVANCES IN THE PROTECTION OF CATTLE AND OTHER ANIMALS AGAINST DISEASE.

[PAPERS FROM THE IMPERIAL INSTITUTE OF VETERINARY RESEARCH, MUKTESAR (*Director*, MR. J. T. EDWARDS ; *Secretary for Publications*, MR. S. K. SEN).]

II*

Some Points of General Importance in the Hygienic Maintenance of the Domesticated Animals.

1. ATMOSPHERIC FACTORS.

The theoretical basis of the science of ventilation has undergone profound modification as a result of the findings of recent authorities (Leonard Hill, Flügge and others), and the most notable direction in which this has occurred would appear to be that the modern conception of the principles of ventilation involves the abandonment of the belief—a belief that has been held until very recently—that the noxious properties of the air are mainly attributable to the amount of carbon dioxide present in it. The results of these researches, on the other hand, point in the direction of the conclusion that the relative proportions of the chemical constituents of the air are amenable to considerable alteration without any harmful effect being produced upon living beings, the so-called "hygienic" quality of the air being, in reality, determined by such purely physical factors as the temperature, humidity, and movement of the air, or, collectively, what has been termed the "cooling power" of the air. The formulæ that have been taught to veterinary students in the past for the computation of housing space and rate at which an interchange of air is required inside a building must, in the light of our present knowledge, be abandoned. Finally, our present knowledge in regard to the spread of infection by air shows that it is of much less significance than what was believed to be at one time, and, also, that the genesis of specific infectious diseases, such as tuberculosis, is not attributable to bad hygienic conditions, such as "bad" ventilation, but entirely to the proximity of infective materials in "carriers" of the disease. "Bad" hygiene may contribute towards the spread of diseases of this kind, but their eradication must depend entirely upon the detection and elimination of all "carriers." It would seem that the main reason why the incidence of tuberculosis in cattle in India is low is because the conditions in which they are maintained preclude the spread of infection, and not because the infection that does exist in the country is necessarily of a very mild nature. It is not improbable that, with the adoption of

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* The first article in this series appeared in the July (1925) No. of the Journal.

intensive methods of domestication, as at the Government military dairies, with the establishment of conditions for the ready spread of infection from animal to animal, the problem of tuberculosis infection may become a serious one in time. One is rather struck with the intensification that takes place in analogous conditions in the common form of contagious bovine abortion in India.

2. Soil Factors.

In the diseases of the domesticated animals the rôle played by the soil as a medium for the conveyance of infection assumes a position of paramount importance on account of the intimacy with which they come in contact with the soil in the course of their ordinary habits of life.

In German writings on animal disease one encounters frequently the term *Stallseuche* (" stall " or " housing " disease) and *Weideseuche* (" pasture " or " meadow " disease). To the former category of diseases belong such affections as tuberculosis and diseases of the new born, the propagation and the intensification of which are facilitated by the opportunities for passage from one susceptible animal to the other. To the second category belong :—

(1) Affections in which the transmitting agents or vectors are intimately associated with certain types of soil. For example, red-water in cattle is associated with uncultivated lands covered with herbage favouring the development of the transmitting agent, the tick. Fluke disease in sheep is connected with low dampy marshy ground in which abounds the species of freshwater snail in which the fluke parasite must pass a certain phase of its life-cycle.

(2) Affections in which the causal organism of the disease develops or finds conditions favourable for its survival within the soil, for example :—

(i) Black-quarter of cattle. In this affection the causal spore-bearing anaerobic bacterium arises from restricted areas of uncultivated soil.

(ii) " Lamziekte" of cattle in Africa. An interesting example of an incurable paralytic affection of cattle, which, according to the researches of Theiler and his colleagues, appears to be set up by the ingestion of a very powerful toxin generated by certain spore-bearing anaerobic bacteria which are found in restricted areas of *veldt*. In certain areas of this grassland the soil is very markedly poor in phosphorus, and ingestion of pasture grass consequently sets up " pica " in the cattle, *i.e.*, a craving to chew strange objects, notably bones lying about on the *veldt*, which, as has been stated, may contain the powerful toxin generated by the soil bacteria. We understand that a similar condition occurs in cattle in certain parts of India (Bihar) and is probably set up by the same chain of circumstances.

(iii) Tetanus ; gas-gangrene (malignant œdema). The spore-bearing anaerobes which cause these diseases are particularly abundant in richly cultivated soil, though it is doubtful if they actually propagate in the soil.

(iv) Hæmorrhagic septicæmia in cattle; swine erysipelas. The causal organisms of these diseases are believed to propagate in the soil in the form of relatively harmless organisms. When an animal of more than ordinary susceptibility is infected with large numbers of these organisms, perhaps through a lesion in the bowel, the microbes may become powerful enough to set up the disease, and having overcome the defences of the first animal they become greatly exalted in virulence, and when voided in the discharges of the animal they are in a position to invade readily the tissues of a second animal. Subsequently the disease caused takes the form of a veritable outbreak during the season of the year when the opportunities for propagation from animal to animal are best.

(3) Affections of a nutritional character caused by some chemical defect in the soil. From the researches, notably of Per Tuff in Norway, we know that outbreaks of a skeletal disease known as osteomalacia may occur in cattle due to a lack of phosphate in the soil, a supply of which is essential in the foodstuffs for bone formation and for the correct regulation of nutrition, as has been stated above in dealing with "lamziekte." Affections of this kind can be prevented by the administration of substances rich in phosphorus, such as bone-meal or bran.

Finally, in addition to the above two broad epizootiological categories, it is ventured to suggest a third, which may be termed "paddock" disease, in which outbreaks of infectious diseases find the conditions necessary for their intensification and rapid spread in the congestion that occurs when considerable numbers of animals are grazed in small areas of pasture, which, in popular language, become "sick" (horse "sick," sheep "sick," cattle "sick," etc.). Examples are :--

(*a*) Johne's disease in cattle. The organism, an acid-fast bacillus, resembling the tubercle bacillus, and causing a very chronic enteritis with wasting of the affected animal, is voided with the fæces. In sunlit open countries sparsely populated with cattle, it would soon be destroyed by the effects of sunlight or washed by rain into the ground before it got opportunities to infect massively fresh susceptible cattle. In the small areas of pasture land near farmsteads kept for grazing or exercising of house-fed cattle at all seasons, and probably well sheltered from the sun in many places, the infection finds, on the other hand, admirable opportunities for propagation.

(b) Contagious abortion of cattle. We now know that the disease is transmitted usually by the ingestion of pasture grass or other foodstuffs freshly contaminated with infective discharges of cows that have aborted. In India, it has been found that infection and clinical abortion are very high indeed when animals are kept in conditions of intensive domestication, as at the Government military dairies, whereas infection is low and clinical abortion negligible in the ordinary conditions of cattle life, in the open.

(c) Many verminous infestations—although, perhaps, these diseases might be more appropriately considered under the second category, " meadow " diseases. What is required for the propagation of infection in most of the commoner diseases of the domesticated animals due to worm parasites is for the egg, or any other stage that is excreted, to be voided into a suitable environment as regards moisture, temperature, and protection from sunlight until the young worm that emerges reaches a stage in its development when it is ripe to infect a fresh host. As will be readily seen, intensification of spread will be facilitated by congestion of the pasture with " carriers," and in this respect worm diseases are notable in that adult animals are highly resistant although they are frequently " carriers," while very young animals are highly susceptible. Hence, in pastures where these conditions obtain, large mortality may be experienced among lambs or calves, due to the so-called " stomach worms," which to the adult animal are relatively innocuous. Likewise, young horses may suffer from anæmia due to infection of the large intestine with small worm parasites.

In the study of hygiene as it affects the health of the domesticated animals there are therefore many factors of the highest importance to be considered, which are of relatively small significance in the Hygiene of man, and the potential qualities of so l as a vehicle for the spread of infection must rank as a study of first-rate importance in determining the factors that are of hygienic importance as concern the domesticated animals.

3. The Drinking Water Supply.

In the case of the domesticated animals, the hygiene of the water supply is of much smaller importance than it is in the case of human beings. The chemical tests and bacteriological examinations carefully prescribed for the examination of a water supply for human beings are aimed at determining whether there is any evidence of recent contamination with fæces, which, if there is, may be the fæces of " carriers " of serious infectious diseases—such as typhoid, bacillary dysentery, or cholera. *Prima facie*, fæcal contamination ought to be of small importance for

the domesticated animals, for wild animals in a state of nature are not beset with any ever-present risks due to drinking water which is almost invariably contaminated in this manner. Moreover, we know now that our animals are not infected with serious bacterial diseases of the kind that man contracts from an infected water supply.

The teaching of methods of water analysis may therefore well be omitted from courses of instruction on veterinary hygiene.

The points that are of importance in so far as concern the health of animals are :—

(1) That the water should be available in plenty, and accessible whenever the animal naturally desires it. It should not be given in large quantities when the animal is fatigued, but otherwise, as has transpired particularly from the researches of Scheunert recently upon the watering of horses, it may be drunk at any time before or after a meal. In the case of working horses, in which the peristaltic action of the bowel may be easily disturbed, it is rather important to water the animals with regularity.

(2) That the water supply should be clean, and free from gross suspended particles, notably sandy particles, as are present in large quantities in water pools in which animals are allowed to " puddle " while drinking. These particles tend to settle in the large compartments of the bowel and may cause severe " sand-colic," or, short of that, the accumulation of earthy matter in the bowel interferes with peristalsis and digestion and brings about marked unthriftiness in condition.

(3) That the water supply should not be allowed to stagnate. This statement refers particularly to the condition which is likely to arise in low-lying pastures where there is at certain seasons of the year a constant thin layer of water covering portions of the grazing land. The condition is ideal for the development of worm parasites, which, as has been stated in discussing the hygiene of the soil, are responsible for an infinite amount of disease or unthriftiness in the domesticated animals. The remedy is good drainage and general good agricultural husbandry. It is noteworthy that the so-called sewage poisoning which was said to affect cattle often on sewage farms in England turned out to be, on closer investigation, verminous gastritis or enteritis, or, sometimes, Johne's disease.

The above desiderata may be considered to be the chief ones, but there are numerous minor ones, for example :—

(1) Excessive " hardness " of water is probably injurious.

(2) Throwing of carcases into water-courses is a dangerous procedure, for they may be infected with anthrax, and a large area of grass land on the

banks of the river, particularly when it recedes after the rainy season, may become infected in this manner with anthrax spores.

(3) Avoid public watering troughs for horses, particularly in towns where glanders is prevalent. We know now that glanders is transmitted by the ingestion of material recently contaminated with the discharges from the nostrils, usually, of glandered horses. Hence, the risks of infection through the medium of water in a public trough, which may have been used a short time previously by a glandered horse, are very great.

THE SOUTH ANDAMAN COCONUT SLUG-CATERPILLAR (*THOSEA UNIFASCIA*, WLK.).

BY

P. V. ISAAC, B.A., M.Sc. (Lond.), D.I.C., F.E.S.,

Second Entomologist (*Dipterist*), *Pusa.*

At the suggestion of the Imperial Entomologist, an enquiry into the slug-caterpillar pest of coconut palms in South Andaman was undertaken by the writer. About six weeks from 17th February, 1925, were spent in South Andaman and neighbouring islands in the study of the insect and the trial of control experiments.

The Insect.

The insect *Thosea unifascia*, Wlk., belongs to the Family Limacodidæ. In its fully developed stage it is a dark brown robust moth. This moth is seldom seen, as it avoids daylight and is active only at night. But during its growth it passes through a larval period when it is a leaf-green spiny slug-like caterpillar feeding on certain kinds of foliage including that of the coconut palm. The caterpillar is found on the underside of the leaves, where it feeds quite exposed, growing to an inch in length when mature, but escaping notice by having nearly the same shade of colour as that of the leaf and also because its movements are very slow.

Nature of injury.

These caterpillars feed voraciously and at times may occur in such large numbers in coconut plantations that a great many trees over a restricted area may be almost entirely defoliated. The mature spread-out leaves are preferred to the more tender central ones, and the caterpillars eat almost the whole of the green blade, leaving only the bare thin mid-ribs on the leaf-stalks. At first only a few trees are attacked, but these caterpillars turn into moths and successive generations of caterpillars in increased numbers are produced and the pest in a few months spreads over a large area, infesting every tree, and the injury done to the trees becomes both extensive and acute.

Occurrence of *Thosea unifascia*, Wlk. in South Andaman.

It was in February 1922 that *Thosea unifascia*, Wlk., was first noticed as a pest of coconut palms in South Andaman. In the Minnie Bay Plantation at Port Blair, Mr. A. T. Wernigg, the lessee, found some time after a thorough weeding that 9,000

of his palms had numbers of a green slug-caterpillar feeding on their leaves—very soon the palms were almost completely skeletonised. The damaged leaves were removed. All this happened during the dry season. By August 1922 after the monsoon rains had started the pruned palms appeared quite leafy and healthy. The pest disappeared for some months. During 1924 in March it reappeared in North Bay Plantation at Port Blair damaging 8,000 palms, and in September in Minnie Bay Plantation, Port Blair, on 6,500 palms, and in Mitha Kheri Plantation, Port Blair, on 3,500 palms, and in October in North Bay Plantation on 25,000 palms. These occurrences do not signify any definite progress in either the multiplication or the spread of the insect pest but mark the occasions when it did serious damage as observed by Mr. A. T. Wernigg who has to be greatly commended both for his careful enquiry into the habits of the insect and his persistent efforts to check the pest which made him finally to approach the Imperial Entomologist as well as the Chief Commissioner of the Andaman and Nicobar Islands with the request for the scientific investigation of the insect. The caterpillars were abundant in all the three plantations mentioned above during February 1925 when the present investigation was taken up, but were not spreading to healthy areas.

Coconut plantations in South Andaman.

The coconut plantations in South Andaman of any magnitude are all within the settlement of Port Blair. There are about 3,850 acres of land under coconut cultivation. The plantations belong to and were till recently managed by Government but since 1922 nearly 3,200 acres have been leased out to free settlers. The land was originally under forest and was cleared for coconuts. The plantations are some about fifty, some about thirty-five, some about nine years old. There are also a few acres which have been only recently planted. In most places there has been a good deal of undergrowth and there was hardly any attempt at cultivating the soil. The plantations are all along the coast and on small hills or sides of hills which rise up to about 300 feet from the sea. The soil is rather close in texture. As there is no system of terracing there is nothing to prevent surface wash, and since Port Blair receives a rainfall of about 115 inches in the year the soil denudation is considerable and consequently the land is extremely poor in organic matter. The coconut palm is an introduced plant in South Andaman and observations show that it is not grown under satisfactory soil conditions. Besides, there are about one hundred palms planted to the acre, whereas the ideal recommended by experienced farmers is about sixty to the acre. The average yield of nuts has therefore been low.

The life-history and habits of *Thosea unifascia*, Wlk.

When palms grown under the conditions referred to above have also an insect enemy to contend with it becomes very necessary to find ways and means for check-

FIG. 1. The coconut plantation in North Bay, Port Blair, South Andaman.

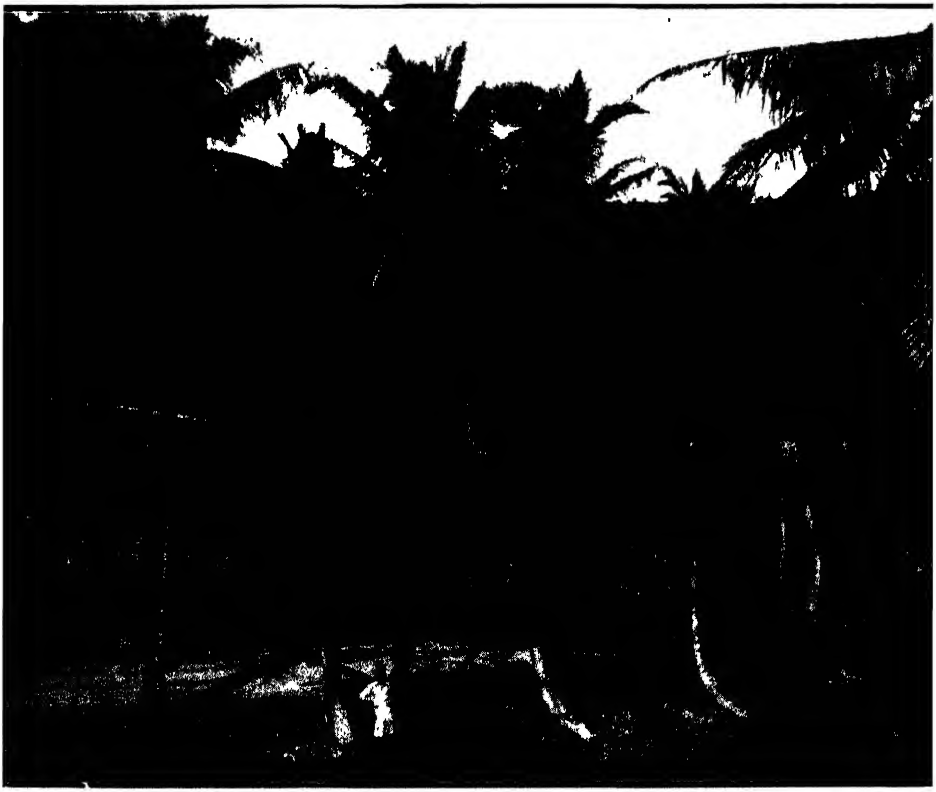
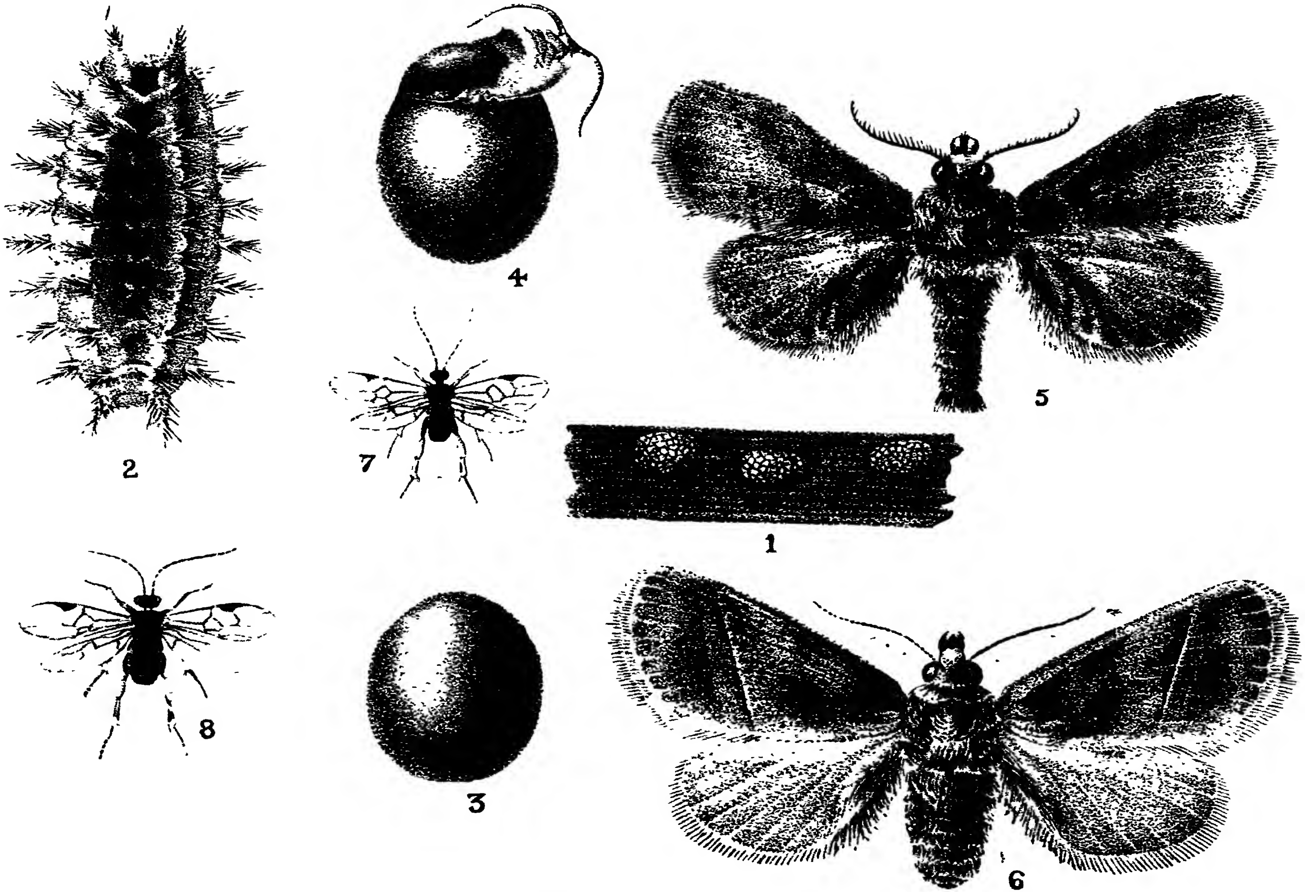


FIG. 2. A few coconut palms damaged by the coconut slug-caterpillar in North Bay Plantation.

PLATE XXVIII.



THE SOUTH ANDAMAN COCONUT SLUG-CATERPILLAR.

, Three eggs as laid on palm leaf ; 2, Full-grown caterpillar . 3, Cocoon ; 4, Cocoon from which moth has emerged, showing lid and part of pupal cuticle 5 & 6. Moth, male and female ; 7 & 8, Braconid parasite, male and female ; (all 3).

ing the pest, and for success in this endeavour it is of the greatest importance to possess a thorough knowledge of the life-history and habits of the insect. Owing to the shortness of the period spent on the study of this pest there are many points on which information is lacking; a full knowledge of this pest can be arrived at only after continuous research; and meanwhile a statement of what is already known of the bionomics of this insect will not be without interest.

The egg. (Pl. XXVIII, fig. 1.) A female moth lays about 400 eggs, scattered singly and occasionally two together on the lower surface of the leaves of the coconut palm or other plant whose leaves also serve as food for the caterpillar that hatches out. Each egg is oval and scale-like with minute reticulations on its surface and lies flat on the leaf. Its greatest length is 3 mm. and greatest breadth is 2 mm. The egg hatches in about five days.

The larva. (Pl. XXVIII, fig. 2.) Out of the egg the young caterpillar hatches out and immediately begins to feed on the leaf, first eating a small surface patch and then consuming continuously portions of the leaf-blade, avoiding the mid-rib. The very young larva is covered with regular rows of branching spines and except in size very much resembles the full-grown larva. As it feeds and grows it moults a number of times. The full-grown larva is about 25 mm. long and about 10 mm. broad. In colour it is leaf-green with a median dorsal yellowish stripe bearing a few brightly coloured spots. The head is usually withdrawn into the body, the ventral surface is fleshy and dull white. On account of these features the larva is called a slug-caterpillar. There are a large number of branching spines on the body, arranged in two longitudinal dorsal rows and also all round the margin of the slug-like body. The four anterior bunches of spines are reddish. The spines have a very slightly irritating effect on the human skin. The caterpillar stage lasts about eight weeks.

The pupa. (Pl. XXVIII, figs. 3 and 4.) When the caterpillar is fully mature it moves from the leaf and crawls down in search of a dark situation where it can pupate. On a coconut palm it often finds the internal axil of the leaf-stalk quite satisfactory but some caterpillars crawl down the trunk and burrow up to four inches deep into the soil at the base. Before pupating the caterpillar spins around it an almost globular, brownish-black cocoon which is about 10 mm. long and 8 mm. broad. Although the cocoon looks uniform in texture it is so built that one end could be pushed out as a lid. The caterpillar now moults again and becomes a pupa which marks an apparently quiescent stage in the life of the insect. The pupal period is about 21 days, and when this is over the fully formed moth breaks through the pupal cuticle and pushes open the lid of the cocoon and flies out.

The adults. (Pl. XXVIII, figs. 5 and 6.) The moths are nocturnal and powerful fliers. They have no proboscis and do not feed. They are reddish brown in colour. The female has a very stout abdomen. The antennæ in he female are very slender but in the male they are feathery, of the kind termed bi-pectinated. The male

also has in the middle of the fore-wing a dark spot which is not found in the female. The wing expanse in the male is 30 mm. and in the female 36 mm. The male is generally smaller than the female but the size in both sexes varies to some extent.

Life-cycle. Each generation takes about 12 weeks to develop, about five days as egg, about eight weeks as caterpillar and about three weeks in the pupal stage.

Broods. One generation quickly follows another and there seem to be four broods in the year, the moths appearing during or about the months of March, June, September and December. Variation from this rule happens as a result of dearth of food or unsuitable climatic conditions, and it is quite likely that while in one locality there are full-grown caterpillars in another a few miles away there may be young caterpillars.

Foodplants. Besides infesting coconut palms, the caterpillars feed on leaves of *Barringtonia racemosa,* Roxb. This and perhaps one or more other non-cultivated plants are very likely the natural foodplants of the caterpillars.

Natural enemies. A small wasp-like insect belonging to the family Braconidæ parasitises these caterpillars. The Braconid thrusts its eggs into the young caterpillars, one in each. The larva that hatches out feeds on the internal organs of the caterpillar and slowly kills it. The larva matures a little before the caterpillar dies and it leaves the host and pupates in a white silken cocoon it spins just below the caterpillar and attached both to the leaf and to the ventral surface of the host. The caterpillar dies shortly and a few days later the adult parasite emerges from the cocoon. This adult probably feeds on the nectar of flowers. When the caterpillar pest becomes abundant in some localities a great many half-grown caterpillars killed by the parasite may be seen stuck to the leaf by means of the parasite's cocoon.

This parasitic Braconid is sometimes attacked by a smaller insect, a member of the super-family Chalcidioidea. The larva of this hyper-parasite feeds on the internal tissues of the Braconid grub and kills it after it has cocooned. A large number of hyper-parasites emerge from one Braconid cocoon.

Birds gather in numbers where caterpillars are on the increase and feed on them. Chief among these are crows and mynahs. But there are not a great many of these birds on the island.

A wilt disease of bacterial or fungoid origin kills a great many caterpillars when they are numerous. Attacked caterpillars become flaccid and die and their bodies which still stick to the leaves turn black and decay.

Discussion of remedial measures.

Although there is no previous record either of this caterpillar pest or of the occurrence of the moth in the Andaman Islands, there is no reason to think that it is an introduced insect. The likelihood is that it is indigenous and that it fed normally

on some wild plants and that natural forces maintained a balance of life between this and the other forms of life associated with it. The appearance of this insect as a pest in all the three plantations in Port Blair followed extensive and thorough weeding operations. Is it possible that the moths which avoided sunlight and kept themselves to the low growing bushes of wild undergrowth, now they were removed, flew higher up and laid eggs on the palm leaf which by its suitability as food for the caterpillar as well as its abundance conduced to the extraordinary multiplication of the insect? Or might it be that the weeding had a temporary bad effect on the Braconid parasite and thereby relaxed one important check on the caterpillars and that in course of time this check again becomes effective? Without further investigation it is impossible to bring speculations of this nature to any reasonable conclusion. Apparently this insect is a sporadic pest, it suddenly increases in numbers, spreads, does considerable damage during a short or long period and then is subdued by natural forces.

The immediate necessity has been to find some method for checking the pest when it does occur and also to find some remedy in the early stages of any fresh outbreak. From what is known it is possible to devise methods for checking any outbreak in its initial stage and preventing widespread damage. As the caterpillars stick to the undersurface of the leaflets and as young palms are the first to be attacked they are easily noticed. When only a few palms are attacked those leaves which have caterpillars on them may be cut down and immediately burned over a fire which can be easily lighted in a coconut plantation. If caterpillars are not present in great numbers it is possible to go over the infected area, and clip off leaflets on which caterpillars exist by means of tree pruners mounted on long poles and worked from the ground either by a thin wire or strong cord. These leaflets should be gathered and promptly thrown into a fire. An attempt was made to burn the caterpillars by means of torches. It was found that caterpillars were not always killed and many leaflets were often entirely damaged, and at times the labourers employed set fire to the crowns of the palms.

The pupa is also amenable to attack. It is found generally within the leaf-base and at times in the soil close to the tree trunk. When in an infected plantation caterpillars are noticed quitting the leaves to pupate a great many cocoons in the crown may be destroyed by means of a long knife of the kind generally used by labourers who may be put on to clean the trees. The cocoons in the soil are easily collected by hand with the aid of a small hoeing tool.

The moths come to artificial light on dark nights in numbers. Simple light traps consisting of a wind-resisting lantern, like the Dietz hurricane lantern, over a tub of water with a film of kerosine oil on it will catch a number of these moths. These traps will be found very effective in places where a generation of caterpillars has appeared and there is the possibility of an emergence of a brood of moths. One such light trap to about four acres of infested area will be enough, and it should be kept going for about two weeks.

The Braconid parasite in the case of sporadic outbreaks of the slug-caterpillar increases and brings down the number of caterpillars without human intervention. But if the caterpillar establishes itself anywhere as a pest, the parasite can be easily reared in a specially constructed breeding house and released where it is required.

Crows and mynahs are at present rare on the island. The former is however not a very desirable associate for man. But an increase of the mynah population may be an advantage. As regards the wilt disease past experience is against the practicability of finding in a bacterial or fungoid disease a possible control method against any insect.

Control methods recommended.

Of the remedial measures discussed, those mentioned below should be practised by all coconut growers when faced with an outbreak :—

1. As soon as caterpillars are noticed destroy them by either cutting down whole leaves or leaflets and throwing them into a fire.
2. Destroy the cocoons to be found within the leaf-axils or in the soil close to the tree trunk.
3. Use light traps and kill the moths.

Conclusion.

There are many points in the bionomics of *T. unifascia*, Wlk., which can only be rightly understood by further research. This is the first time the insect has been known to occur as a pest. Owing to the fact that the problem of this insect is confined to the South Andaman Island, which is about 500 square miles in area, enquiry into the details connected with this insect and its habits opens a very fruitful field for entomological work. Moths of *T. unifascia*, Wlk, have been collected from Rangoon, Moulmein and Bhamo. There is no record of its habits or of the appearance and foodplants of the caterpillar. In Rangoon the moths of a closely allied species, *T. sinensis*, Wlk., have been reared from larvæ fed on rose leaves. In 1906 a related insect, *T. cinereamarginata*, Banks., was described as a form new to science, and it is said that its caterpillars fed on and did considerable damage to coconut palm leaves in the Philippines.

Acknowledgments.

I have to acknowledge my indebtedness to Mr. A. Mujtaba and Mr. Md. Shaffi, Assistant and Fieldman, respectively, in the Entomological Section, Agricultural Research Institute, Pusa, who accompanied me on the tour of investigation and gave me all help. My sincerest thanks are due to Mr. A. T. Wernigg of Port Blair for

placing at my disposal all the information he had gathered and for the assistance he constantly and most willingly gave me. I have also to thank Messrs. A. K. Wernigg and A. C. Wernigg for their hearty co-operation in carrying on my work on their plantations at North Bay and Mitha Kheri.

To Col. M. L. Ferrar, C.I.E., the Chief Commissioner of the Andaman and Nicobar Islands, I owe a very deep debt of gratitude for all the help the local Government departments gave me, for many suggestions based on his own intimate knowledge of agricultural conditions in the Andamans and for much personal kindness.

SUGAR BEET AND ITS POSSIBILITIES IN BIHAR.

BY

PHANI BHUSAN SANYAL, M.Sc.,

Assistant to the Imperial Agricultural Chemist.

In considering the possibilities of sugar industry in India from sources other than cane, the Sugar Committee in 1920 came to the conclusion that "with the possible exception of the Nipa palm, which may in the future repay investigation in Burma, the only alternative sources of sugar in India of practical interest are the palmyra palm, the Indian date palm and the sugar beet."

From the work that had already been done on sugar beet in the North-West Frontier Province and the Punjab they further concluded that "the future of the sugar beet in India lies, if anywhere, in the North-West Frontier Province and the Punjab." The Punjab results were, however, rather inconclusive; but encouraging results had been obtained at Peshawar where a favourable yield was obtained and fertile seeds produced. The Committee, therefore, were of opinion that there was a promising field for starting a combined cane and beet factory in the Peshawar Valley, and they finally recommended that "the beet experiments should be continued there under more diversified agricultural conditions and closer chemical supervision." In the course of the beet experiments at Peshawar with which the writer has been associated since 1914, it was noticed that the crop withstood even the severe extremes of temperature which prevail at that place and that the water requirement of beets is much lower than that of sugarcane. These considerations led the writer to attempt the cultivation of sugar beet at Pusa. They were grown for the first time as a garden crop in 1923. The analytical results were very interesting and it was decided to grow the crop on a field scale next year.

Sugar beet at Pusa, 1922-23.

Description	Average weight of a root lb.	Per cent. fibre in root	Per cent. juice in root	Per cent. sucrose in root	In Juice			
					Brix	Per cent. sucrose	Per cent. glucose	Purity
Sutton's seed . .	1·23	6·20	93·80	15·86	20·04	16·91	0·10	84·37
Peshawar seed . .	0·74	8·12	91·88	13·83	19·19	15·06	0·11	78·46

The experiments which began in 1923-24 were devised to study the possibilities of beet sugar industry in Bihar and elicit information specially on the following points :—

(1) The length of time during which sugar beet of good quality would be available in Bihar.
(2) The best time for sowing the seeds.
(3) Yield of roots per acre.
(4) The effect of distance of rows on the quality and yield of roots.
(5) Comparison of Peshawar seeds with those obtained from Messrs. Sutton & Sons.
(6) An idea of the approximate cost of production.

For these experiments a loamy soil was selected in the Silk House Area at Pusa. The plots received an application of farmyard manure at the rate of 400 mds. per acre. Ploughing and cross-ploughing the land were done with the help of the Punjab plough. The plots were then harrowed and beamed and ridges made with a double mould-board plough. The latter were next opened with a hand plough to the depth of 3 inches and sown 2-3 inches apart with seeds which had been soaked in water for six hours. These were covered with soil and pressed with the hand and the plots were immediately irrigated with water, the level of which in the trenches was not allowed to rise more than 4 inches below the top of the ridges.

The germination, which commenced after 3 days of sowing and continued for a week more, was on the whole satisfactory. The fields were kept free from weeds and the crusts were broken after each rainfall. Six to nine irrigations, according to the need of the crop, were given during the six months they were in the field. The plants were thinned and finally kept at a distance of 6 inches to 8 inches.

There were five plots, each ⅛th of an acre, which were sown as follows :—

Plot I. With Sutton's seed at 8 lb. per acre in rows 1 foot 6 inches apart, on 5th September, 1923.

Plot II. With Sutton's seed at 8 lb. per acre in rows 1 foot 6 inches apart, on 5th October, 1923.

Plot III. (*a*) Western half of the plot with Peshawar seed at 15 lb. per acre and (*b*) the eastern half with Sutton's seed at 8 lb. per acre in rows 2 feet apart, on 12th October, 1923.

Plot IV. With Sutton's seed at 8 lb. per acre in rows 1 foot 6 inches apart, on 5th November, 1923.

Plot V. The plants taken out from Plot III during its thinning were transplanted in this plot. This plot had received a dose of 300 lb. of superphosphate per acre in addition to the farmyard manure.

Excepting in the northern portion of Plots I and II, where there previously had been a stand of mulberry plants, the plants were quite healthy and attained a height of more than 1¼ feet in the course of three months, and by the end of the

fourth month the roots grew quite thick and long. A view of the field in 1923-24 is shown in the annexed photograph.

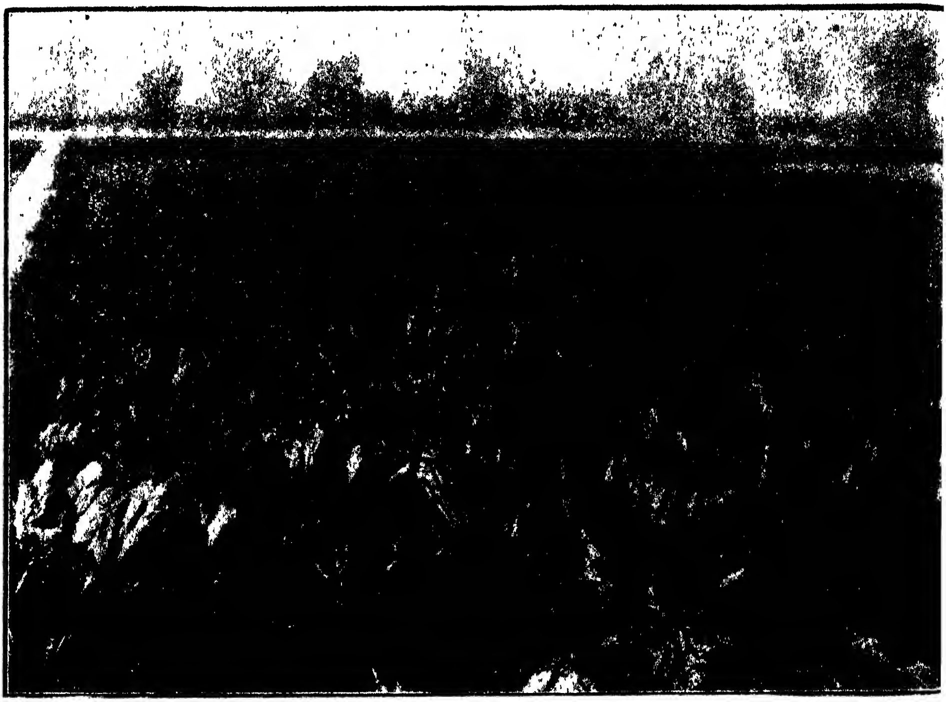


FIG. 1. A view of the beet field at Pusa, 1923-24.

The analysis of the roots began when they were four months old. Fortnightly samples were taken and their examinations continued till sometime after maturity had been attained. The results are tabulated below.

Sugar beet at Pusa, 1923-24.

	Plot I	Plot II	Plot III (*a*)	Plot III (*b*)	Plot IV	Plot V
Yield (mds.) in ¼th acre	31·85	39·63	35·40	40·05	35·88	39·57
Yield (tons) per acre (82⅔lb. = 1 md. and 27·286 mds. = 1 ton).	9·34	11·62	10·38	11·74	10·52	11·60
Per cent. sucrose in roots	14·56 (from 18-2-24 to 12-3-24)	14·85 (from 19-2-24 to 12-4-24)	15·32 (from 25-2-24 to 26-4-24)	14·80 (from 7-2-24 to 26-4-24)	15·30 (from 26-2-24 to 19-5-24)	13·74 (from 26-2-24 to 5-5-24)
Purity of juice	84·01	8480	84·69	85·07	86·01	84·00
Tons sugar per acre	1·360	1·726	1·59	1·738	1·61	1·594

In Plot I the yield was decidedly smaller than that in the others. The plot had carried a plantation of mulberry and a large number of mulberry roots had to be picked out from the soil in this area.

The results of these experiments are rather promising, and the following observations may be made :—

(1) Beet roots of good quality, shape and yield were produced from both the varieties of seeds sown in the months of October and November. The annexed photograph shows the size and shape of three roots, weighing $2\frac{1}{2}$ to $3\frac{1}{4}$ lb. each, grown in 1923-24.

FIG. 2. Three beet roots from Plot II Pusa, 1923-24.

(2) The results of the fortnightly analyses showed that, although the sowings were done at different periods, the crop matured practically

all at the same time in the various fields, *viz.*, about the end of February. A sowing had been done in Plot I in September, but the crop here too matured in the end of February. In this case, however, some trouble was incurred owing to the rains which followed after sowing and more labour had to be employed in hoeing and weeding.

(3) The crop could be retained in the field without deterioration for a long time. In Plot IV the crop which matured in the middle of February was allowed to remain till the middle of May, and during all these three months the quality was found to be maintained in good condition.

(4) Practically no difference in the total yield or in the quality of roots could be found whether they were grown in rows at a distance of 1½ or 2 feet from each other. The only difference observed was in the size of roots, longer spacing being associated with bigger roots.

(5) Roots grown at Pusa from Peshawar seeds appeared to be slightly better in quality than the mother beets from which they were collected. The Pusa crop contained 15·32 per cent. sucrose (average of four analyses from 25th February to 26th April), while the original beet at Peshawar contained 14·62 per cent. sucrose (average of 9 analyses at Peshawar in May and June, 1923).

(6) The roots can safely be grown up to three pounds in weight without any apprehension of the sucrose content being abnormally lowered. In the case of the three roots shown in the photograph and which weighed on an average 2·83 lb., the juice contained 19·54 per cent. total solids, 17·06 per cent. sucrose, 0·1 per cent. glucose and its purity was 87·33 per cent.

(7) The transplanted roots in Plot V were found to be all branched and though their average weight was almost the same as that of the roots in other fields, the former generally contained less amount of sucrose. Two of the transplanted roots had flowered at Pusa. One such root with its flower is shown in the following photograph.

A careful account of the expenses incurred in growing beet in different plots was kept. Irrigation and manure were supplied free by the Estate. Six to nine irrigations were given in six months. If the cost of irrigation and manure be calculated at local rates and the actual cost of seed as paid to Messrs. Sutton & Sons be taken into account, the total cost per acre producing about 11 tons of beet root comes to Rs. 148. There is a likelihood of this amount being substantially reduced. Further experiments started this year (1924-25) have indicated that it is possible to reduce the expenses under the items of manuring and irrigation without seriously reducing the yield. Again, if seeds be procured direct from Europe there will be a further saving of about Rs. 20. The total cost of producing beet roots will thus not exceed Rs. 12 per ton. The price paid for a ton of beet roots last year (1923-24)

in America was 8·1 to 13·99 dollars or Rs. 25 to Rs 44 according to the quality of the roots and the locality in which they were grown.

FIG. 3. A branched beet root with flower-head grown at Pusa, 1923-24.

For the sake of comparison, factory returns obtained in various countries in 1923-24 are entered in the following table. These data have been collected by the Bureau of Statistics, U. S. Sugar Manufacturers' Association, 901, Union Trust Building, Washington.

As no factory trial was made of Pusa beets, the figures for the approximate raw sugar extraction per cent., percentage of sugar on beet expected to be recovered and the pounds sugar per acre which an efficient factory can recover, are calculated from the figures applicable to Nebraska and Utah where the roots are similar in

composition. It will be seen that these calculated figures for Pusa beets compare very favourably with those of the foreign countries.

Sugar from beets, 1923-24.

Countries	Yield of roots per acre	Per cent. sucrose in root	Purity of juice	Raw sugar extraction per cent. of weight of root	RECOVERED	
					Per cent. sugar	Sugar per acre
	Tons					lb.
California	9·52	18·35	82·94	17·33	94·44	3,288
Colorado	12·17	14·59	82·34	12·73	87·25	2,932
Michigan	8·10	15·29	84·40	13·51	88·36	2,021
Nebraska	11·03	14·48	82·38	12·32	85·08	2,536
Utah	12·95	15·66	85·02	13·59	86·78	3,299
U. S. A.	10·66	15·34	83·43	13·41	87·42	2,681
Germany	9·98	..		15·70	..	3,133
France	12·51	..	(1922-23) ..	13·84	..	3,464
Japan	..	..	..	10·00	..	..
Australia	11·59	..		11·29	..	..
Pusa	11·06	15·00	(1923-24) 85·12	13·00*	86·00*	3,248*

* These figures represent probable amounts and are calculated from the Nebraska and Utah figures, as in purity of juice and sucrose content the roots from these places are similar to those analysed at Pusa.

A brief discussion about the possibilities of the beet sugar industry may be made here.

Originally beets, from which Achard, about a century and a quarter ago, first produced sugar, contained only about 6 per cent. sugar. The aid of scientific research has been sought in systematically increasing the sugar-content of beet root till the present figure of more than 22 per cent. (up to 26 per cent.) has been attained. It is expected that at Pusa too it would be possible to increase the yield of sugar to figures considerably higher than those obtained during the course of present experiments.

The existing cane sugar factories in Bihar are at a disadvantage inasmuch as the sugar season is very short. Owing to the advent of a very dry summer canes cannot be kept in the field here after the month of March without deterioration. It has now been shown that sugar beet of good quality can be made available till the end of May. Manufacture of sugar from beet may thus be made to follow the cane season. It would not be impossible to introduce suitable modifications in the existing factories (*e.g.*, provision of slicing machinery, diffusion apparatus, filter press, etc.) and thus prolong the working days of the sugar mills by two months more.

Besides the above, which is one of the strongest reasons for taking up the cultivation of beet in India, there are other cogent reasons in its favour :—

(1) It is a six months' crop, whereas cane occupies the ground for about a year.

(2) Its manurial requirement is smaller than that of cane; moreover, the leaves and exhausted pulp may be fed to the cattle and afterwards returned to the land as farmyard manure.

(3) Its water requirement is much less than that of sugarcane.

(4) Work in the beet field is more congenial than in the sugarcane field, and labour would thus be more easily available in the case of the former crop.

(5) It can stand drought and frost better and no fear of lodging need be apprehended during rains and storms, as is the case with cane.

(6) It improves the tilth of the soil and leaves it in an excellent condition for the following crop.

(7) It yields a valuable green fodder.

It has, however, one drawback in that its cultivation on a wide scale cannot be undertaken without the previous establishment of a factory. The cultivation of beet sugar does not lend itself to the adoption of a cottage industry, like the making of *gur* from cane.

Attempts, however, are being made at Pusa to evolve a simple method for making *gur* or *rab* from beet.

The writer's thanks are due to Babu Brajaraj Mukherjee, the Estate Overseer, for carrying out the agricultural operations in connection with these experiments.

SELECTED ARTICLE

AGRICULTURAL RESEARCH IN RELATION TO COMMUNITY.*

BY

SIR DANIEL HALL, K.C.B., F.R.S.,

Chief Scientific Adviser to the Ministry of Agriculture, England.

IT is a common reproach that agriculturists have not made the same use of science as have those engaged in the other great industries -- that farming is still a rule-of-thumb process carried out by methods which have their origin in the dark backward and abyss of time. In some respects this is indeed true. One has only to read Cato or Columella to realize that the Italian peasant of to-day is working and living in very much the same way as his Roman forebears, and even the more highly organized farming of Great Britain or Denmark or Holland is carrying on many of the essential operations of cultivation on lines that were laid down by the first great civilizers — the Romans. It is easy in fact to trace modern agriculture to a Roman ancestry; in Britain, for example, by the transplantation from the fifteenth century onwards of the traditions and practices that persisted through the dark ages in the Low Countries.

Nonetheless progress has taken place and scientific development is going on. Under medieval systems of agriculture the yield from England's land was of the order of six to eight bushels of wheat to the acre. The enclosure of common lands, the introduction of a recuperative clover crop into the rotation and of forage crops like turnips for the winter feeding of cattle and the making of farmyard manure, the return to Roman methods, in fact, raised the level of production to about twenty bushels of wheat per acre. This was about the average when agricultural science dawned nearly a hundred years ago—say about 1840, when Liebig exposed his theory of plant nutrition and Lawes began his experiments at Rothamsted. Growing scientific knowledge and the introduction of fertilizers raised the level of English production by 50 per cent. during the next generation, so that by 1870 the average yield of wheat per acre in England had become thirty-two bushels. At that level it has more or less remained down to the present day because a new factor then came into play, the importation of cheap wheat through the opening up of the Middle West of the United States, and of Argentina and of Australia. The economic

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factors of gold scarcity and rising costs of labour co-operated to limit the profit attached to high farming: the English farmer had to cheapen his production and lower his standard so that he only obtains the same yield to-day, though the acreage under wheat has shrunk on to the better land. Latterly we have seen the yield creeping up a little through the introduction of heavier cropping wheats—the products of scientific research.

In other directions there has been progress. The introduction of the self-binder alone has meant great economies in man power. I estimate that by the use of machinery in one way or another English farming, with an equal or greater output, employs some 25per cent. less labour than it did fifty years ago. Cattle feeding is more economic. Breeding for early maturity, better adjustment of rations either for meat or milk production, have all tended to a cheaper output. There is still an immense margin for improvement. From scientific experiments one may calculate with some degree of confidence how much meat and milk a given quantity of fodder of one kind or another ought to yield. Yet when in the dark days of the war we took stock of our resources in cattle food, because tonnage could no longer be spared for aught but human food, soldiers or munitions, it was estimated that in the five years before the war the farmers of the United Kingdom at large only realized one-third of the meat and milk that was theoretically possible from the fodder that had been then available.

Disease amongst animals is another field in which research has not been idle; enormous savings have been effected in the average efficiency of our flocks and herds. Yet last year Great Britain had to pay a bill of approximately £20,000,000 to stamp out foot-and-mouth disease, and this was compensation only for slaughtered animals and took no account of the losses the farmers endured by the break-up of their businesses.

Great are the achievements and still greater the possibilities of agricultural research, but we must recognize that there are limitations to the effect of science upon agriculture which do not hold for the other industries. In the first place, in agriculture we are dealing with a living organism and the amount of control that we have obtained over plant or animal, over that stubborn essence we call life, is far less than we can exercise over inanimate nature, over iron or cement, over even the ether or the atom. When we attack vital problems we find that we cannot speed up processes or enlarge the unit in the way we can deal with the dynamo or spinning frame. It still takes the wheat plant six or nine months to develop, and cows bring forth their calves neither more quickly nor more numerously for us than they did for Abraham. We see no way of growing three or four crops a year under temperate climatic conditions. The organisms we are dealing with will go through their cycle and you cannot hurry them. When you start hustling you find you let in secondary troubles of all sorts.

These limitations lie in the nature of things, and though on looking back we can count up the immense advances that agriculture owes to the application of knowledge,

we must not hope for sudden developments or revolutionary changes such as have been seen in flying or wireless telegraphy. In fact, for the time being I am bound to say that agriculture is actually suffering from the rapid developments and scientific achievements that have distinguished other industries. I say this advisedly and most solemnly. Agriculture is the fundamental industry, because we must all be fed, and yet you cannot point to any part of the world where agricultural wealth is being turned out and find the producers in a flourishing condition.

The rewards in agriculture, whether to the capitalist entrepreneur or to the labouring man, are not commensurate with those obtainable in industry or commerce, and so men are being drawn away to the towns and capital is being diverted from the farms. The movement is one common to all civilized countries, its sources are social as well as economic. The lure of the town has been secular, but modern facilities of communication and transport have given it a range of action hitherto unknown ; yet it cannot go on for ever, for the world must be fed. One must interpret the steady rise of food prices which has marked this century, a rise now being resumed after the excessive fluctuations caused by the war, as evidence that we are approaching a limitation to the development of the towns because there is not food enough to go round.

The old economists would see a simple solution to this impasse ; prices of food have only to rise sufficiently and men will be attracted back to the land in order to secure the profits it promises—the balance will be restored. But looking back historically, has this ever happened ? I can find no example of an urban population migrating into the country. If the countryside does replenish itself in men it is by breeding and by finding space in the country for the country-bred. The great increase in the food supplies of the world the last half century has witnessed has been due to the new countries becoming accessible, whereby opportunities were given to the rural population to put their sons on new land. But that process is nearly at an end, there are no longer the great vacant areas waiting for men.

Are we not to look for progress in another direction ; can we not so intensify the farming of our existing land by taking advantage of science, machinery and organization that agricultural production will become an industry capable of competing against other industries for men and capital ? It was by a process of this sort, by enclosing the common lands and building up small capitalist businesses, that Great Britain succeeded a century and half ago in meeting the needs of a population which was then beginning to expand as the industrial age approached. Our businesses have remained small, too small to be efficient to-day perhaps, and I can point to few examples of large scale industrial farming in successful operation.

In fact, though I pin my faith to big business on the land as necessary to the future production of food in order to meet the growth of cities, I am bound to say that the current seems sweeping in the other direction. Agricultural businesses, such as we have, find it difficult to pay the wages that will retain men on the land, with all its disadvantages of quietness and lack of amusement. Social and economic

motives in our country are working towards the break-up of farming businesses into single-man or rather family farms, and similar forces have been even more powerfully at work in Continental countries in dividing up the land. The desire of men for independence, the determination to call no man master, the innate feeling among country folk that a man has a right to a bit of land of his own as he has a right to a vote or to a soul of his own, makes in many countries the single-man holding a burning political question. And the man is ready to pay—to pay in labour, in days that endure from dawn to dark, in days that include the hours of his wife and children, in toil as against the regular pace of a factory, for the privilege of being a landowner.

But I doubt whether the process is fundamentally economic. Farming may become immediately more intensive when a great estate is cut up into small holdings, but the community so created becomes an unprogressive one, little fitted to take advantage of modern science, modern machinery, modern organization. It is fundamentally uneconomic because it is employing more men than are necessary to produce the food on which the community can be supported. I conceive it to be possible for 15 per cent. of the working population to be able to produce the necessary food for the rest of the nation, and the larger the margin that remains after this prime task has been performed of men who can be making boots and clothes, houses and motor cars, the greater the divisible wealth of the community.

But the only hope I can see at present for large-scale production, for organized industry on the land, lies in the advances that science can make. It is research alone that will enable the big agricultural business to compete with the excessive labour of the one-man farm, to pay wages and give conditions of life to its workmen equal to those prevailing in the urban industries. It becomes then a matter of the first import to the growth of civilization itself, not merely to agriculture, that agricultural research should be encouraged.

We may consider research from two points of view. In the first place, it is an intellectual affair carried out by the individual in response to the insatiable curiosity of the mind about its surroundings and its own existence. As such it proceeds from an artistic impulse, it is not under control and it is not amenable to considerations of utility. Just as some men must write poems or paint or make music, as other men find themselves compelled to speculate, to become philosophers or metaphysicians, so similarly the class of men we are considering must investigate nature.

The passion to do this is part of the man's make-up and cannot be created by any act or will on his part. I may remind you of the story of the old school-fellow who met Dr. Johnson at the height of his fame. "Doctor," he said, "I have often tried to become a philosopher myself, but cheerfulness will keep breaking in." And as a man cannot deny himself a desire to investigate, so he is not drawn to investigation by any ulterior motive.

I may take an illustration in the science of astronomy. Historically the study of the stars would appear to have had its beginnings in the search for useful knowledge.

In the early civilization of Egypt it was necessary to find out a means of determining exactly the length of the year and the recurrence of the seasons. Later on the delusive promises of astrology led to further observation, and as we know, the first organized observatories were built for the service of the sailor for the drawing up of what we call a nautical almanac. But these prime necessities were easily satisfied and the real science of astronomy cannot for the last hundred years have served any useful purpose to any man. Nonetheless, the development of the science and the foundation of observatories has proceeded at a greater pace than before, purely in response to the universal feeling of curiosity. Oddly enough, this kind of knowledge has proved itself singularly attract ve to the American millionaire, who has latterly been the great founder of observatories. Indeed the uselessness of astronomy is to many people one of its great attractions. A great astronomer once said to me, " One advantage I enjoy is that my science cannot make money for anybody—at least no merchant traffics in my heart." We may parallel th's feeling with the remark of some noble lord who was being congratulated on his elevation to the Garter, " The best of the Garter is that it implies no damned nonsense about merit."

Research again possesses this quality in common with what are usually called the arts - its characteristic mental process is intuition When we were students we used to be told that the two processes of thought by which science proceeded were deduction and induction. It was pointed out that the barrenness of the medieval schoolmen was due to the fact that they worked by deduction alone from imperfect premises. Bacon became the father of modern science by recalling it to induction and to the painful collection of facts. Bacon's apothegm was recalled, " Hypothesis non fingo," and it was suggested that the method of science was to collect an assemblage of facts and put them into some kind of sorting machine, whereupon a theory will emerge. However, a little examination of the actual history of discovery soon shows that it does not proceed in such a fashion. The function of facts is to provide tests for your hypotheses, but you cannot begin to collect the facts unless you have preliminary hypothesis.

Let me take an example in the science of meteorology. For generations people made observations of the weather, set down the records of temperature, rainfall, barometric height and so forth. Nothing whatever came of these facts until in the study one or two workers evolved from their own consciousness the theory of the cyclone. Induction in fact failed. Bacon's other great catchword, " Experimentum crucis," showed that he really had a better appreciation of the true processes of science, and the really beneficial influence he exerted upon the early science of the seventeenth century was that he directed men's attention to experiment and to the mechanic arts as the sources of knowledge. To come back to our text, neither induction not deduction complete the story of the mental processes by which investigation proceeds. We now realize a third category in the shape of intuition, the power of seizing the truth by a sudden flash of illumination. Indeed, the great discoverer may be a man in whom what is commonly called the scientific habit of mind is

imperfectly developed. He may not be severely logical, methodical in his arrangement of facts, meticulous in accepting deductions.

As a recent example we may instance the late Sir William Crookes, whose marvellous discoveries certainly did not proceed by a process of minute but steady accretions from known foundations. By a sudden jump of mind he invented the radiometer, regarding which his explanations were mistaken, but his intuition led him from this point on to the whole gamut of high vacuum discovery which has resulted in such developments as the Röntgen rays, the elucidation of the structure of the atom, wireless telephony, etc. Sir William Ramsay provides another instance. In the eighteenth century Cavendish had noted that after removing all the oxygen and nitrogen from air a small residuum was left uncombined. In true scientific spirit he put this down to the inevitable errors of the experiment. But working on the same track and worrying over the discrepancy between the atomic weights of nitrogen obtained from different sources, Ramsay's intuition led him on to the discovery of argon and the range of new light elements.

So far I have only been considering research from its intellectual side as a response to man's curiosity, but the nineteenth century proved it had also a practical side inasmuch as it led to an enormously increased control over the forces of nature. I need not sing the praises of what has been effected by steam, by electricity, by modern medicine; willynilly the results are being incorporated into our daily life. Research leads to efficiency, and efficiency is a means of making money. The modern State must cultivate research if it is to become efficient and survive in the world's competition; hence all are agreed now on the endowment of research, and since in farming there are no great business corporations, agricultural research must for many years to come be maintained by the State.

If, then, research is to become of such importance to the State, it behoves us to ensure conditions for the research worker under which discoveries are likely to be produced. To do this properly we must understand the psychology of the investigator. If it is true that research, like art, grows by a process of intuition, we can no more organize it into existence than we can organize the output of poetry. Nor are we likely to obtain it by a system of prizes, or rewards, commensurate to those obtained in the great professions, in industry or commerce. What we can do is to contrive sheltered places in our community in which research workers can live. We cannot guarantee results, but we may wait in faith because, as we have said, the impulse to make discoveries is fundamental in man's mind. Now the sheltered places in which the research worker can live are the universities.

One last word, the State must have research in order to obtain efficiency, but does mankind really care about efficiency? At bottom man does not, he wants to "loaf and possess his soul." Efficiency is a beautiful word, but efficiency to what end? If pursued for its own sake it may become a curse. Many people have vivid recollections of the sufferings they endured under a really efficient parent in an efficient household. I, myself, am officially engaged in promoting efficiency, in

bringing up the efficient farmer and in insuring the efficient use of the land. But I cannot help having a great deal of sympathy with the old-fashioned farmer, who is content with what the land brings him, who is making his living but not worrying overmuch about making money. He is often inefficient, but again he is often a very worthy human being.

To take another illustration, I have a vivid recollection years ago of a little piece of swampy meadow, half encircled by a brook, which after other wanderings found its way into the Thames. There was a patch of reeds and willows, an old salley garden, where the reed warbler swung her nest and flitted through the tangled herbage. The wet meadow itself was starred over in August with Grass of Parnassus. It was indeed one of the most southern holds of that flower of the cool northern hillsides. Well, the efficient man came along, saw his opportunity, grubbed up the willows and laid out the meadow in watercress beds. He is a benefactor of his kind and has caused millions of blades of an edible kind to grow where there was none before; but I have a sore spot in my heart for the vanished warblers and the lost Grass of Parnassus. I fear, however, that the pursuit of efficiency is one of those contradictory elements in man's make-up that won't let him rest, that is always urging him against his will towards further attainment. What a dreary prospect if it only results in adding an ever greater and greater population to a world always working harder and harder! Is there any way out of this inpasse? I can only again suggest the kindly force of that other element in the texture of men's minds, the passion for artistic expression. The winds of beauty come and go, but as they rustle through the tree of life, among the dropping leaves that are ourselves, men will cease from their toil to listen and pause to retell in song or story, in paint or stone, the message they bring.

NOTES

THE WATER-HYACINTH AND ITS UTILIZATION.

IN a recent review [1] of the work done by the Agricultural Department in India during the last twenty years, attention was directed to the profitable utilization of the water-hyacinth in increasing crop-production in Bengal. The suggestion was thrown out that this water weed should no longer be regarded as a pest to be destroyed but should be converted into valuable manure for jute and rice by means of the Chinese methods of composting crop residues described by King in *Farmers of Forty Centuries.* The matter was referred to in *Capital* of January 22nd last (p. 131) and again on February 5th by Dr. Gilbert Fowler in his article on the water-hyacinth problem (p. 242).

In connection with a series of experiments at the Institute of Plant Industry, Indore, on the conversion of crop residues into finely divided organic matter suitable for the cotton crop, results have just been obtained which leave no doubt that the profitable utilization of the water-hyacinth in Bengal and in Burma is a practical proposition. In the Indore experiments, one of the materials employed was water weed obtained from the local river. This was mixed in the fresh condition with earth, cow-dung and wood ashes in the Chinese fashion in a compost heap. To begin the heap five cart loads of the weed were spread on the ground in the form of a rectangle—eighteen feet by twelve—and about nine inches deep. Half a cart load of earth, half a cart load of ordinary farm-yard-manure and two baskets of wood ashes were then spread uniformly on the weed, moistened with water and the whole mixed. A second layer of water weed was added and again mixed with moistened earth, cow-dung and wood ashes as before. This procedure was continued till the heap contained from thirty to forty cart loads of the weed. The heap was then lightly covered with earth to prevent excessive drying and left for a month. An active fermentation at once began and the water weed was rapidly broken down into a damp moist mass. At the end of the first month the heap was turned to promote thorough aeration. By the end of the second month the fermentation was completed and the water weed was converted into finely divided organic matter resembling moist leaf mould. This material when added to the soil stimulates growth in a remarkable manner and is proving a valuable manure.

There is every reason to believe that the above treatment would produce similar results if applied to the water-hyacinth in Bengal and Burma. The only modification likely to be necessary is to adjust the moisture in the water-hyacinth before

[1] *Crop-production in India,* Oxford University Press, 1924.

composting so as to prevent water oozing from the heap. If this takes place a loss of valuable material would result. This loss could easily be prevented by allowing the weed to wither for a few hours in the sun before being used for the compost. The best time of the year to convert water-hyacinth into Chinese compost would be after the monsoon between October and March when the work could be carried out in the open air. During this period a large volume of compost could be prepared for the cold weather crops, for the jute areas, for rice nurseries and for vegetable and fruit gardens.

It will naturally take some years before the ryots of Bengal realize the great value of the water-hyacinth in increasing crop-production. A beginning however can be made at once by many private individuals interested in gardening and fruit growing. The experience thus obtained will soon begin to filter down to the people. If at the same time organizations like the Universities, the Agricultural and Co-operative Departments and Agricultural Associations take up the work, progress will be rapid. At all Agricultural Exhibitions in Bengal substantial prizes should be offered for the best compost made from the water-hyacinth and for produce raised with this manure. [ALBERT HOWARD in *Capital*, dated 18th June, 1925.]

SULPHATE OF AMMONIA IN JAVA.

THIS is the principal fertilizer used on the cane lands in Java and is imported from several countries. The table* below gives the imports of this artificial manure into Java during the three years 1922, 1923, 1924. It will be seen that the demand for sulphate of ammonia in that island is increasing every year and that Great Britain and the United States of America are now the principal suppliers. India is also improving its position as a supplier, as will be seen from the steadily rising figures of imports therefrom.

Supplying country	1922	1923	1924
	Tons	Tons	Tons
Great Britain	35,726	45,074	43,344
United States of America	23,646	20,056	42,845
Holland	3,423	9,603	13,574
Germany	..	3,136	7,590
Belgium	100	1,633	..
Italy	..	..	465
British India	853	1,785	3,012
China	130	..	..
Japan	5,390	..	..
Australia	1,472	254	1,117
TOTAL	70,740	81,541	111,947

* Taken from the *Netherlands Indies Review*, V, No. 11.

It is a matter of great regret that sulphate of ammonia, which is available as a by-product in the coal and iron working districts of Bihar and Bengal, is not utilized as fully in this country as it should be. In view of the fact that $AmSO_4$ contains 20-21 per cent. nitrogen and that its price is roughly Rs. 200 per ton, *i.e.*, about Rs. 7-8 per maund, while castor cake which should contain on an average 5 to 5½ per cent. nitrogen stands at Rs. 4-12 to Rs. 5 per maund, the great cheapness of this artificial manure per unit of nitrogen will be obvious to all. In North Bihar, the Sugar Bureau took steps to introduce this fertilizer last year and already there are indications that large cane growers have begun to appreciate its use as a manure. Two cwt. of this manure given per acre at the break of the rains where cane is grown without irrigation produces striking results. [WYNNE SAYER.]

NOTE ON AGEING OF CATTLE IN INDIA.

MY excuse for this note is the fact that cattle in India cut their permanent incisor teeth much later than cattle in England.

I suppose most people in India who have had anything to do with the cattle of the country have noticed this fact, but so far as I am aware no one has ever attempted to determine the approximate ages at which Indian cattle do cut their incisor teeth. At any rate I have not been able to discover any publication bearing on the subject.

Most text-books for Indian students so far as they deal with the subject at all appear to simply quote from English works, the dentitions tables quoted having no special reference to Indian cattle.

Even that very excellent War Office Manual "Animal Management," which deals largely with Indian conditions, and should be in the hands of every Indian stock-owner, is remiss in this particular, and states that the temporary central incisors are replaced by the permanent ones at 18 months, that the second and third pairs follow rapidly, and that the corners may be delayed till the animal is nearly 4 years old. This statement for India is altogether misleading.

Cattle at the Government Farm at Hissar from which my statistics have been obtained are all ranch reared. They are seldom or never handled between the ages of 9 months and 2½ years, so that I am not in a position to quote figures as to the dates at which the central permanent incisors are cut (it is probably at about the age of 2 years), but the figures below show that animals with 8 broad teeth are practically always over 4 years and a half, and that the second and third pairs follow much less rapidly than they do in England.

For the same reason that the cattle are ranch reared, I am only able to examine their mouths when they are taken up either to break in or castrate. Hence I am not able to give statistics based on periodical examinations, which is probably the most satisfactory method of determining the ages at which the teeth are cut.

I have, however, in the last 18 months examined the mouths of 477 cattle, of which I know the exact age, all having been branded with serial numbers, and their dates of birth entered in the farm registers.

I give the results below :—

All the cattle examined were between the ages of 28 months and 62 months.

Of these, *6* only had 8 permanent incisor teeth.

The youngest was 51 months ; the oldest 62 months. The average age of these with 8 teeth was 57·6 months.

One hundred and fourteen young bulls and bullocks had 6 permanent incisor teeth with no sign of the corners coming. The youngest of these was 36 months ; the oldest 60 months. Only 13 were under 44 months, 49 were over 48 months, and 33 were over 52 months. Their average age was 47·2 months.

Of *25* heifers with 6 permanent incisors, only the youngest was 42 months ; the oldest 60 months. Their average age was 49·2 months.

It appears that Indian cattle rarely cut their third pair of permanent incisors till they are over 3½ years old, and that the fourth pair (the corners) usually appears nearly a year later.

Among 216 young bulls and bullocks with 4 permanent incisor teeth only, the youngest was 29 months ; the oldest 56 months. Only 21 were under 36 months, 103 were over 42 months, and 4 were over 48 months. Their average age was 41·5 months.

Among 41 heifers with 4 teeth, the youngest was 34 months ; the oldest 48 months. Only 2 were under 36 months, and 27 were over 42 months. Their average age was 40·7 months.

Indian cattle do not usually cut their second pair of incisor teeth till they are over 3 years old.

Among 71 young bulls with 2 permanent incisor teeth only, the youngest was 28 months ; the oldest 42 months. Sixty-eight were over 30 months, and 12 were over 36 months. Their average was 32·5 months.

Four heifers had 2 teeth only. The youngest was 36 months ; the oldest 44 months.

I deduce from the above statistics that Indian cattle rarely cut their central pair of permanent incisors till they are over 2 years old. The intervals between the centrals and the second pair and between the second and third pairs are longer than 6 months.

The intervals between the third and fourth pairs are usually nearly 12 months.

Animals with 2 permanent incisors only should be aged 2½ years ; with 4 permanent incisors only, 3½ years ; with 6 permanent incisors only, 4 years ; with 8 permanent incisors (corners just in wear), 5 years.

My thanks are due to M. Mohamad Ashfaq, 1st Farm Overseer at the Government Cattle Farm, Hissar, for help in collecting the above statistics.
[R. BRANFORD.]

REPORT ON THE FIFTH ALL-INDIA EGG-LAYING TEST.

This annual test was again organized by the United Provinces Poultry Association at Lucknow during the past three winter months—November, December, January, 1924-25. By way of explanation it may be here observed that the objects for which this test is held are fourfold--

(1) To induce the best bred-to lay stock into India.
(2) To encourage breeders in India to keep productive fowls.
(3) To test such birds, so as to have valuable data for future years.
(4) To ascertain the relative costs and profits that may accrue.

The test is unfortunately but a short one as owing to climatic conditions it has not been considered advisable to hold a longer test. The intensely hot climate of Lucknow for seven months of the year is most trying to fowls, therefore the test is arranged for the months of November, December and January, these months being the recognized time when pullets coming into lay will show their true form. A pullet laying 50 first grade eggs during these three months remains a first class layer for the rest of the year in the ordinary course of events, whereas a poor producer during these months is not likely to pay for her keep. The temperature during this season ranges from 85°F. at midday to 34°F at night. Each bird was separately housed in an intensive pen 3 feet × 6 feet and open to the air on all sides, although the pens were ranged in consecutive order, so that the birds can see each other and yet not mix together, every partition being of fine mesh wire-netting.

The necessary exercise is induced by burying the grain ration in the sand litter which is kept well turned over. The birds were fed as follows :—

Morning. 2 oz. of grain per bird.

The grain feed consisted of 2 parts by weight wheat, 1 part cracked maize, 1 part cracked gram. As the imported birds did not take to gram at first, extra wheat was given to them until they began to eat cracked gram.

Midday. A large bunch of green food was given to each hen.

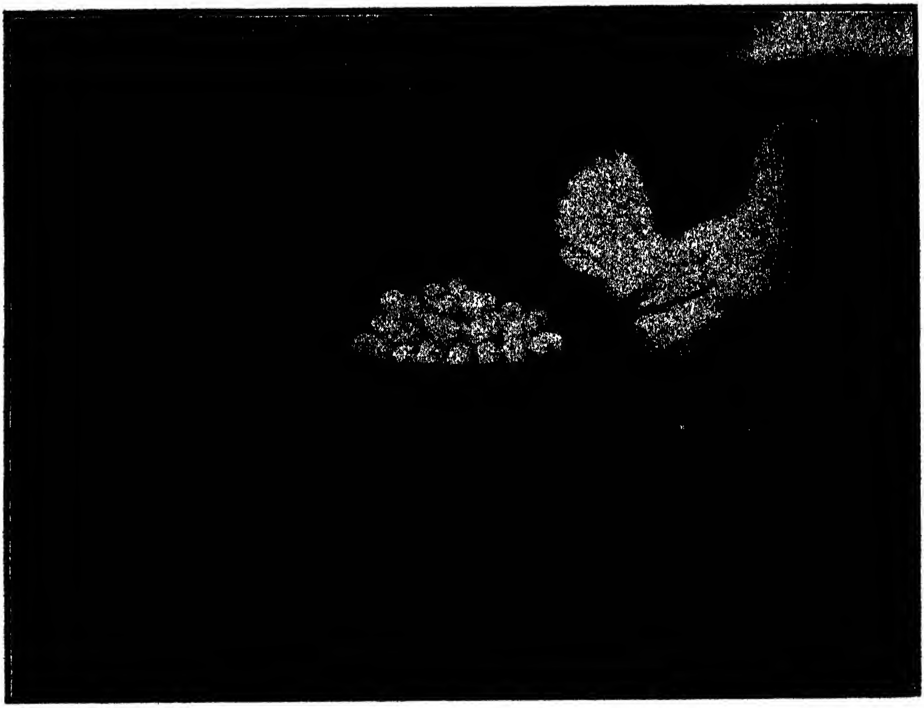
Afternoon. Soft mash as much as the birds would eat :—

	Parts
Bran by weight	2
Coarse flour of wheat	4
Maize meal	1
Gram flour	½
Fish meal	½

Green vegetables were boiled and just enough of the resulting liquor was added to moisten this mash to a crumbly consistency ; great care was taken to avoid any undue moisture or slopiness. The green food given was country spinach and *mehndi.*

Once a week chopped onion at the rate of 1 oz. per bird was added to the mash. A half teaspoonful of Epsom salts per bird was also dissolved in the vegetable liquor and added to the mash once a week.

In all there were 65 entries or pens ; among these, 16 entries were from Great Britain, three from Australia, and the remainder from Indian bred birds. In all 3,164 eggs were laid, an average of 48·5 per hen. Every year we have increased our average, our first test averaging 37·25 eggs per hen only.



Winner of the Governor's Cup—White Leghorn pullet owned and bred by Captain Mayo. Laid 68 eggs in 92 days.

The breeds competing were :—White Leghorns, 31 ; White Wyandottes, 5 ; Australorps, 7 ; Light Sussex, 8 ; Rhode Island Reds, 4 ; White Orpingtons, 4 ; Other Light Breeds, 6.

The average production in terms of first grade or 2 oz. eggs for each breed was as follows :—White Leghorn, 43·4 ; White Wyandotte, 52·0 ; Australorp, 48·4 ; Light Sussex, 42·7 ; Rhode Island Red, 39·8 ; White Orpington, 35·5 ; Other breeds, 35·8.

The winner of the test as regards number of eggs laid was a White Leghorn pullet laying 68 eggs ; she, however, lost points as regards size of egg, and the winner of the test as regards the number of first grade eggs was an Australorp laying 62·2 eggs according to points for size of egg. She was closely followed by a White Leghorn pullet with 61·6 eggs. The rules of the test are that 20 per cent. of eggs weighing below 2 oz. are cut from the score.

All birds kept excellent health and no deaths occurred. The cost of feeding and labour was as under :—

	Rs.	A.	P.
Hard grain and meals	34	0	0
Shell grit and charcoal	11	0	0
Fish meal	10	5	0
Green food	69	0	0
Onions	2	7	0
Epsom salts	3	4	0
Labour	42	0	0
TOTAL	172	0	0

Total receipts by sale of 3,164 eggs at Rs. 1-8 per dozen were Rs. 395-8-0.

The birds sent from overseas were sold at the conclusion of the test ; the highest price realized was £5 per bird, and the average price realized was 2 guineas per pullet. Special cockerels for mating were sent out with most entries.

To readers of our efforts overseas we would explain that this is the first organized effort to interest and teach the public about the possibilities of poultry farming. The Indian people, especially Hindus, look on the fowl as unclean and the egg as untouchable so that progress is difficult, though we are glad to say that some students on our farm are drawn from the highest caste called Brahmins and they have violated their principles and become some of our best pupils. Slowly but surely education is breaking down barriers and the demand for eggs and table fowls is increasing. The local fowls are very small, and though hardy are not good layers ; they have developed broodiness to an extraordinary degree. Good foodstuffs for poultry are available though not the same as those of other countries ; oats are not much cultivated but pulses and millets take their place. Our work is largely experimental and climatic conditions are trying in many parts of this vast country. Parasites such as the fowl tick, scaley leg mite, lice etc., abound, and chicken-pox, roup, tick fever and cholera are very prevalent. It is only by constant supervision and the greatest attention to sanitation that we can keep going. We welcome entries to our test from all parts of the world. Our next test commences on 1st November, 1925, and full particulars will be sent on application to Secretary, U. P. Poultry Association, Lucknow, India.

PERFORMANCES OF PULLETS ENTERED FOR THE EGG-LAYING TEST, 1924-25.

Owner	Breed	Pen No.	Gross total	Total to score	Remarks (Birds laying over 50 eggs gain 1st class certificate)
Warwick Rogers, England	White Leghorn	1	61	59·0	Winner of team prize special No. 4. No. 4 also won special prize No. 10.
	Ditto	2	59	57·0	
	White Wyandotte	3	50	45·2	
	Ditto	4	61	59·8	
F. R. Welch, England	Light Sussex	5	40	38·8	
	Ditto	6	55	54·8	1st class certificate.
	Ditto	7	58	46·4	
	Ditto	8	46	44·0	
Lord Dewar, England	White Leghorn	10	46	38·2	
	Ditto	11	47	46·8	
	Ditto	12	16	15·8	
	Ditto	13	37	35·8	
W. Bradbury, England	White Leghorn	14	38	30·6	
	Ditto	15	60	61·6	Won special prizes Nos. 8 and 7.
	Light Sussex	17	52	45·6	
	Ditto	18	50	47·0	
L. A. Ellis, Australia	White Leghorn	19	61	58·8	This pen is the finest in the test, having highest average. Big type and large combs. Three 1st class certificates.
	Ditto	20	60	59·6	
	Ditto	21	62	58 4	
Raja Bahadur, Mursan, U. P.	White Wyandotte	23	57	48 6	
	Ditto	24	56	48·2	
	Rhode Island Red	25	47	42·4	
	Ditto	26	33	32·4	
U.P. Poultry Assn., Lucknow, U. P.	Rhode Island Red	27	61	53 2	1st class certificate.
	Black Leghorn	28	44	41·6	
	Australorp	29	54	51·0	1st class certificate. No. 30 also won special prize No. 6.
	White Wyandotte	30	66	58·4	
Miss Stehelin, Dehra Dun, U. P.	Light Sussex	31	27	27·0	
	Rhode Island Red	32	31	31·0	Won prize No. 11 for points in type.
	Light Sussex	33	39	38·6	
F. C. D'Almeida, Delhi	White Leghorn	34	44	38·8	
	Ditto	35	36	30·4	
M. U. Khan, Lucknow, U. P.	White Leghorn	36	60	49·4	Very good team. Four 1st class certificates. No. 37 won prize No. 5.
	Ditto	37	62	52·0	
	Ditto	38	51	49·4	
	Ditto	39	53	44·8	

PERFORMANCES OF PULLETS ENTERED FOR THE EGG-LAYING TEST, 1924-25 —*concld.*

Owner	Breed	Pen No.	Gross total	Total to score	Remarks (Birds laying over 50 eggs gain 1st class certificate)
Mrs. Grain, Ranikhet, U. P.	Australorps	40	64	62 2	Team excellent except for No 43. Three 1st class certificates No. 41 won special prizes Nos. 2, 8, 9 and 12.
	Ditto	41	64	63·0	
	Ditto	42	60	57·2	
	Ditto	43	27	26·8	
P. W. Meakins, Dehra Dun, U. P.	White Leghorn	44	44	41·6	
	Ditto	45	38	35 2	
	Ditto	46	46	44.4	
	Ditto	47	57	52·4	1st class certificate.
G. Duncan Terry, Simla	White Leghorn	48	50	46 4	
	Ditto	49	39	36 2	
Capt. Mayo, Nahan, Punjab	White Leghorn	50	61	53 2	1st class certificate
	Ditto	51	57	49 6	
	Ditto	52	33	31·8	
	Ditto	53	68	59 6	Winner Governor's cup.
C. Lawrie, Jhansi, U. P.	White Leghorn	54	57	47·0	Excellent team. Three 1st class certificates.
	Ditto	55	47	44·6	
	Ditto	56	52	43·0	
	Ditto	57	64	54 0	
F. Mackenzie, Ghorasahan, Bihar	Australorps	58	47	46 6	Good type.
	Ditto	59	38	33 4	
R. G. V. Burnside, Ghazipore, U. P.	Brown Leghorn	60	42	33 6	
	Ditto	61	45	39 0	
Mrs. Lambert, Ranikhet, U. P.	Black Minorca	62	46	45·6	These birds were sick on arrival and lost ground.
	Ditto	63	37	37·0	
Mrs. Cardew, Lansdown, U. P.	White Orpington	64	48	46·8	Fine layers of large eggs Good layers for the breed.
	Ditto	65	42	33 8	
	Ditto	66	39	32 2	
	Ditto	67	48	39·4	
Mrs. Savaille, Bhadrak	Brown Leghorn	68	22	18·0	

LIST OF SPECIAL PRIZE WINNERS AT THE TEST.

Prizes	*Winners*
1. Cup for the best layer in the test, presented by his Excellency the Governor, United Provinces.	Capt. Mayo, Nahan, Punjab, with White Leghorn laying 68 eggs in 3 months, irrespective of weight of egg.
2. Cup for the best layer from India, presented by the Stewards of Lucknow Races.	Mrs. Grain, Ranikhet, with Australorp laying 63 eggs. Standard eggs, 2 oz. and over.
3. Cup for the best layer from overseas, presented by the Stewards of Lucknow Races.	Walter Bradbury, England, with White Leghorn laying 61·6 eggs.
4. Cup for the best team of four birds entered, presented by Right Hon'ble Lord Dewar, England.	Warwick Rogers, England, 4 birds totalling 231 eggs in 3 months.
5. Cup for the best layer owned by an Indian poultry breeder, presented by St. Geo. Jackson, Esqr., Lucknow.	Muzaffar Uddin Khan, Lucknow, with White Leghorn laying 52 eggs.
6. Cup for the best layer bred from the U. P. P. A. stock, presented by the U. P. Poultry Association.	Won by U. P. P. A. Cup given to runner up Muzaffar Uddin Khan with White Leghorn winner of No. 5.
7. Cup for the best layer White Leghorn, presented by the Raja of Jehangirabad.	Walter Bradbury, England, with White Leghorn laying 61·6 eggs.
8. Cup for the best Australorp, presented by the Austral Orpington Club, England.	Mrs. Grain, Ranikhet, winner of No. 2.
9. Cup for the best Australorp bred from Australorps Farms Ltd., presented by the Australorps Farms Ltd., England.	Mrs. Grain, Ranikhet, winner of Nos. 2 and 8.
10. Best layer heavy breed other than Australorps, presented by the U. P. P. A.	Warwick Rogers, England, winner of No. 4.
11. Best layer that conforms to the Poultry Club standard for its breed characteristics, presented by the U. P. Poultry Association.	Miss Stehelin, Dehra Dun, with Rhode Island Red pullet.
12. Best layer owned by a member of the Indian Poultry Club, presented by the Indian Poultry Club.	Mrs. Grain, Ranikhet, winner of Nos. 2, 8, and 9.

[MRS. A. K. FAWKES.]

CANE MOLASSES RICH IN VITAMIN B.

THE following observations are summarized from an article in "Industrial and Engineering Chemistry," by three American scientists, Mr. V. E. Nelson, Mr. V. G. Heller and E. I. Fulmer, who, as the result of exhaustive biological experiments, have determined the vitamin contents of cane and beet molasses, proving conclusively that the former is far richer than either beet molasses or sorghum in Vitamin B, the absence of which in food is responsible for wasting diseases.

The general opinion prevails that molasses as a food is of value from the energy standpoint only. This is to be expected from the analysis, since the greater portion of the solid matter is composed of sugar and only a comparatively small amount is crude protein. It was deemed advisable to ascertain the degree of concentration of vitamins in this material because of the wide use of molasses in animal feeds and in the human dietary. The data so obtained should not only aid in ascertaining the true value of certain diets, but they should also contribute to our information concerning abundant stores of the vitamins for chemical identification, a problem of considerable importance to the chemist.

Since the vitamins cannot be determined chemically at the present time, the only means available to reveal their presence and concentration is the so-called biological method, which involves the use of small laboratory animals under carefully controlled conditions.

Vigorous rats weighing from 50 to 70 grammes each were used. The following basal diet was employed for the determination of the amount of Vitamin B :—purified casein, 20 per cent. ; filtered butter fat, 5 per cent.; salt mixture, 3·7 per cent. ; various amounts of molasses or sorghum from 5 per cent. up to and including 25 per cent.; and the remainder of the ration to 100 per cent. was composed of dextrin. The striking results that followed can be seen from the accompanying table :—

Ratio	Per cent	Males	Females	Litters	Total young	Young lived	Growth curve
Cane	5	1	3	2	12	..	—
	7.5	1	3	5	30	..	+
	10	2	7	8	41	24	++
	15	8	22	24	168	155	+++
Beet	5	2	2	..	..	..	—
	10	2	4	1	3	..	—
	15	2	8	3	14	..	—
	25	2	3	..	..	..	—
Sorghum	10	1	3	..	..	..	—
	15	1	3	..	..	..	—
	20	3	8	..	..	..	—
	25	2	8	..	..	..	—

The data show that there is considerable difference in the Vitamin B content of cane and beet molasses and sorghum. Cane molasses (blackstrap) is much richer in this vitamin than either beet molasses or sorghum.

Five per cent. of the cane molasses provided a sufficient amount of Vitamin B for growth at slightly below normal rate. Two litters of twelve young were born on this level of intake, but they all died between the fifth and the twelfth day after birth, although they were all perfectly normal when born. When placed on beet molasses at this level the rats gave curves of growth very much below those obtained from cane as the sole source of Vitamin B. Even 10 per cent. of beet molasses failed to provide for normal growth. In fact, the animals failed to grow on this level of beet molasses after the second month. When the amount of cane molasses in the diet was increased to 7·5 per cent., the curve of growth was normal, and the number of young born was greater than on the five per cent. level. However, not a single one of the thirty young was reared.

Better results were obtained when ten per cent. of cane molasses was incorporated in the ration. The growth curves were better than normal and a considerable number of young were weaned.

Anima's have been carried through the third generation on this level of cane molasses. On the other hand, when beet molasses is fed at this level, growth is far below the normal rate and only one litter consisting of three young was born. All of the young on 10 per cent. beet molasses died before they were weaned. The data so far obtained would lead one to believe that higher levels of cane molasses would give even better results, especially from the standpoint of reproduction and rearing of the young. This is actually the case.

In other words, cane molasses (blackstrap) can only be regarded as a very good source of Vitamin B.

By contrast were the results obtained from 15 and 25 per cent. beet molasses and from sorghum. In these cases the deficiency must be actually a shortage of Vitamin B and not a toxicity factor, since the addition of a little yeast caused an immediate resumption of growth. [*The West India Com. Cir.*, XL, p. 103.]

PLANT PROTECTION ORDINANCE IN CEYLON.

The following Ordinance making provision for preventing the introduction and spread of weeds and of pests and diseases injurious to, or destructive of, plants, has been issued by the Ceylon Government :—

Whereas it is expedient to make better provision against the introduction into Ceylon, and against the spread therein, of weeds and of pests and diseases injurious to, or destructive of, plants, and for the sanitation of plants in Ceylon : Be it there-

fore enacted by the Governor of Ceylon, by and with the advice and consent of the Legislative Council thereof, as follows :—

1. This Ordinance shall be cited as "The Plant Protection Ordinance, No. 10 of 1924."

2. In this Ordinance and any regulations made thereunder, unless the context otherwise requires—

"Plant" shall include all members of the vegetable kingdom, whether living or dead, or any part or parts of such, but shall not include canned or preserved fruits or vegetables;

"Pest" shall include any insect or animal which shall in any stage of its development eat, destroy, or otherwise injure any plant;

"Disease" shall include any fungus or organism of vegetable origin which shall injure, destroy, or be parasitic upon any plant;

"Owner" or "occupier" shall include the proprietor, lessee, superintendent or other person in actual charge of any cultivated or uncultivated land;

"Weed" shall include any plant which is declared by the Governor in Executive Council to be a weed for the purposes of this Ordinance.

3. The Governor may appoint for the purpose of this Ordinance one or more inspectors and sub-inspectors and such other officers as may be necessary.

4. It shall be lawful for the Director of Agriculture, or for any inspector or sub-inspector, with or without assistants, to enter, at all reasonable times, upon any land for the purpose of inspecting and examining whether plant pests, diseases, or weeds exist thereon, and the owner or occupier of such land shall afford all reasonable facilities for such inspection and examination.

5. Neither the Director of Agriculture, nor any inspector or sub-inspector, nor any person assisting the Director or any such inspector or sub-inspector, shall be deemed a trespasser by reason of any entry or destruction or action taken or thing done under this Ordinance or any regulation made thereunder, or be liable for any damage occasioned by carrying out any of the provisions of the Ordinance or of any regulation made thereunder, unless the same was occasioned maliciously and without reasonable and probable cause.

6. If any person, without lawful authority or excuse (proof whereof shall lie on him), contravenes any regulation made under this Ordinance, or does or omits to do anything which under the provisions of this Ordinance or of any regulations made thereunder he ought not to do or omit, or if he molests, obstructs, or impedes, or assists in molesting, obstructing, or impeding, the Director of Agriculture, or any inspector or sub-inspector appointed under this Ordinance, or any customs officer, in the execution of any provisions of this Ordinance or any regulation made thereunder, he shall be guilty of an offence against this Ordinance.

7. If any person is guilty of an offence against this Ordinance or any regulation made thereunder, he shall be liable on conviction before a Police Magistrate to im-

prisonment of either description to a term not exceeding three months, or to a fine not exceeding five hundred rupees, or to both.

8. Every person who shall, under pretence of performing any act under the authority of this Ordinance or of any regulation made thereunder, be guilty of any unnecessary violence or cause any unnecessary annoyance to any person, shall be guilty of an offence against this Ordinance.

9. (1) The regulations set forth in the schedule to this Ordinance shall have effect as if the same were contained in this Ordinance, but may be added to, amended, or revoked in the manner, and subject to the conditions, provided for the making of regulations in this section.

(2) The Governor in Executive Council may make regulations for the purpose of preventing the introduction into this island, and for the purpose of preventing the spreading therein of weeds, or of pests and diseases injurious to, or destructive of, plants.

(3) Such regulations may provide, but without detracting from the generality of the powers hereinbefore conferred—

(*a*) For prohibiting the importation into Ceylon from places beyond sea of any plants ;

(*b*) For prohibiting the landing of plants from vessels or boats either absolutely or conditionally ;

(*c*) For providing for the importation of plants under special license and conditions ;

(*d*) For inspecting plants at or before the time of landing ;

(*e*) For cleaning, fumigating, or disinfecting, at the expense of the consignee, and, if expedient, destroying, without compensation, all plants, or the packages, cases, pots, or covering in which they may be packed, which shall be found or suspected to be infected with any pest or disease, and for the recovery of prescribed fees from the consignee ;

(*f*) For requiring the quarantine of imported plants in special areas ;

(*g*) For preventing the outbreak or dissemination of any pest, disease, or weed within Ceylon ;

(*h*) For declaring any area to be an infested area, and for the proper quarantine of any area declared as being infested with any pest, disease, or weed ;

(*i*) For the spraying or other treatment of any weed or of any plants within Ceylon affected with any pest or disease ;

(*j*) For the destruction and proper disposal of any weed or of any plants within Ceylon affected or likely to be affected with any pest or disease ;

(*k*) For regulating the transfer of plants from one locality to another ;

(*l*) For prescribing the officers who are to carry out regulations under this Ordinance, and the powers conferred, and duties imposed, upon them for the purpose aforesaid ;

(*m*) For the constitution of committees to advise the Director of Agriculture and the inspectors appointed under this Ordinance, and to take such other action as may be necessary to ensure its effective administration.

(4) All regulations made under this Ordinance shall be published in the *Government Gazette*, and shall, subject to the provisions of the next following sub-section, from the date of such publication have the same force as if they had been enacted in this Ordinance.

(5) All regulations published as aforesaid shall be laid as soon as conveniently may be before the Legislative Council and may at any time within forty days after the date of their being so laid before the Council, or at any of the three meetings of the Council succeeding such date, by resolution of the Council be disallowed, amended, or otherwise dealt with as may be directed by the said resolution, but without prejudice to anything that may have been done thereunder.

10. "The Insect Pest and Quarantine Ordinance, 1901", "The Plant Pests Ordinance, 1907" and "The Insect Pest and Quarantine (Amendment) Ordinance, No. 30 of 1919," are hereby repealed.

SCHEDULE.

REGULATIONS (SECTION 9).

PART I.

1. *Limitation of ports of entry.* No plants shall be imported into Ceylon, except through the ports of Colombo and Talaimannar.

2. No person shall land or import a living specimen of any insect or invertebrate animal not already known to exist in Ceylon without written permission previously obtained of the Director of Agriculture, provided that the Director of Agriculture or the Director, Colombo Museum, may make such importations as may be required for scientific investigations.

3. *Prohibitions.* No person shall land or import:

(1) Seeds or plants of *Hevea* (any species) from the Western Hemisphere under any circumstances, and from the Eastern Hemisphere, except under permit in writing from the Director of Agriculture previously obtained.
(2) Tea seed directly or indirectly from any place in India.
(3) Coconut plants.
(4) Coconut in husk except through the port of Colombo.

4. *Inspection and fumigation or disinfection.* (1) The following imports shall; before passing out of the Customs, be dealt with as prescribed below :—

(*a*) All living trees, plants, tubers, roots, bulbs, or portions thereof (with the exception of potatoes, onions, ginger, turmeric, and culinary seeds and vegetables imported for consumption), together with the packages, cases, pots or coverings in which they may be packed.

(*b*) All coconuts in husks.

(*c*) The following fruits :—Oranges, lemons, citrons, limes, and all fruits of the *Citrus* family.

(*d*) The following seeds :—Cotton (all species of *Gossypium*).

(2) In the case of an importation of plants, otherwise than through the post, from a country whose service of plant inspection is recognized for the time being, each consignment shall be accompanied by a certificate issued after inspection, and not more than fourteen days prior to the date of shipment, by a duly authorized official of the country whence the plants are exported to the effect that such plants are free from pests or disease. Such certificate must be produced to the Customs Officer at the port of entry. A list of countries whose service of plant inspection is recognized shall be published in the *Government Gazette*, and may be added to or varied by the Director of Agriculture.

(3) In the case of consignments imported through the post, a copy of the prescribed certificate need not be produced to the Customs Officer, but a copy must be affixed to each package.

(4) The certificate shall be transmitted by the Customs Officer to the Inspector in charge of the Colombo Fumigatorium.

(5) The inspector in charge of the Colombo Fumigatorium may open and examine the contents of any consignment or package imported or believed to have been imported, notwithstanding the fact that the consignment may be accompanied by or the package may have attached thereto the duly authorized copy certificate.

(6) In the case of the importation of plants from a country where no recognized service of plant inspection is maintained, and in the case of a consignment of plants which is not accompanied by copy certificates as above mentioned, or of a package of plants imported through the post to which a copy certificate is not attached, the plants before passing out of the Customs shall be subjected at the Colombo Fumigatorium to inspection.

(7) Any imported plants which on inspection are found to be unhealthy or attacked by any pest or disease shall be subjected to fumigation or disinfection as may be deemed necessary by the inspector.

(8) Any imported plants which in the judgment of the inspector cannot be cleaned by fumigation or other treatment shall, with the packing and package, be destroyed at the expense of the consignee.

(9) When fumigation or disinfection or other treatment is necessary, it shall be carried out at the Colombo Fumigatorium, and it may be competent for the

Director of Agriculture to order that after such fumigation or disinfection the plants shall be grown for a period of quarantine in special nurseries provided for that purpose or approved by the Director of Agriculture. The said plants after landing at the Customs premises shall be conveyed to the Fumigatorium under Customs supervision at the expense of the consignee or his agent and delivered to the Fumigatorium Attendant, who shall certify receipt of the same. The consignee shall pay the fee of R 1 a day or part thereof (up to 4 P.M.) and thereafter at the rate of 25 cents an hour for supervision. As soon as possible after receipt of the articles by the Fumigatorium attendant, they shall be inspected by the inspector and fumigated or disinfected when necessary. After inspection or treatment the articles shall be delivered to the consignee, together with a certificate showing that they have been so inspected or fumigated or disinfected, and without such certificate or certificates no article shall be conveyed from the Fumigatorium. A fee of 50 cents per package will be charged to cover the cost of fumigation or disinfection, and no certificate of fumigation or disinfection shall be granted until the fee shall have been paid in such manner as the Principal Collector of Customs may direct. All disinfection or fumigation shall be carried out at the risk of the consignee, and the consignee or his agent shall be in attendance to unpack the articles for inspection, fumigation, or disinfection and to re-pack them afterwards, and shall provide the cooly labour necessary for handling the articles during the process of inspection or fumigation.

(10) When any plants are sent to Ceylon through the Post Office from a place beyond Ceylon, the plants shall be conveyed to the Fumigatorium under Customs supervision at the expense of the consignee or his agent, and shall be dealt with as prescribed above.

India is not included in the list of countries whose service of plant inspection is recognized for the requirements of the above-mentioned regulation.

REGULATIONS, RESTRICTIONS, ETC., FOR IMPORTATION OF PLANTS INTO UGANDA PROTECTORATE.

THE following summary of existing legislation, devised to prevent the importation into Uganda of insect pests and diseases, is published for general information. Full particulars may be obtained from the Entomologist, Box 5, Kampala, or by consulting the following Ordinances and Rules in the Official Gazette :—

	PAGE
Importation of Plants	21, 1908
" "	2, 1911
Plant Pests Ordinance	317, 1912
Notice No. 435	467, 1912
" " 88	110, 1914
" " 274	299, 1915
" " 525	503, 1922
" " 249	294, 1923
" " 250	294, 1923

Definition of the term "plant."

The term "plant" is applied to any cutting, cane, bulb, seed, root, or other parts of plants capable of use for propagation of plants.

Regulations, etc.

The importation of any plant from Ceylon without prior written sanction of the Governor is prohibited.

The importation of coffee plants (or parts thereof other than roasted beans or ground coffee) sugarcane plants, *cotton seed, cotton lint or seed cotton,* is prohibited except with the written sanction, previously granted, of the Director of Agriculture. This does not apply to the coffee passing in transit through the Protectorate but in such instances special packing is necessary.

The importation is prohibited, from all countries where the pink bollworm of cotton is known to occur, of the following plants or parts thereof :—

Hibiscus esculentus, Linn. ("okra," "bandakai", or "bamia").
Hibiscus cannabinus ("teel" or Indian hemp).
Hibiscus Sabdariffa, Linn. ("kirkade" or "rozelle").
Althœa rosea, Cav. (hollyhock).
Thespesia populnea.
Abutilon species ("hanbuk" or "balbij").

NOTE.—Pink bollworm is known to occur in :—

Tanganyika Territory ; Sudan ; Egypt ; Nigeria ; and other West Equatorial African countries India ; Ceylon ; Zanzibar ; Philippine Islands ; Straits Settlements ; China ; Hawaii Mexico ; United States of America ; Brazil ; and the British West Indies.

All plants imported must be submitted to the Entomologist, Kampala, for inspection immediately on arrival, and they may be fumigated or otherwise treated as may be considered necessary. Importers should therefore arrange for consignments of plants to be delivered to, and removed from, the office of the Entomologist, excepting when the plants arrive by post in which case the plants are submitted for inspection by the postal authorities prior to delivery.

Exportation of plants.

Various regulations and prohibitions are in force which affect the importation of plants into the United Kingdom and other countries, and in some instances certificates of inspection are required to accompany such consignments. Full particulars may be obtained from the office of the Entomologist.

IMPORTATION OF UNGINNED COTTON INTO INDIA BY SEA PROHIBITED.

In exercise of the powers conferred by sub-section (1) of section 3 of the Destructive Insects and Pests Act, 1914 (II of 1914), the Governor General in Council

is pleased to direct that the following further amendment shall be made in the order published with the notification of the Government of India in the Department of Revenue and Agriculture No. 580-240, dated the 26th June, 1922, namely :—

For paragraph 11 of the said order the following shall be substituted, namely :—

"11 (1) Unginned cotton shall not be imported by sea.

(2) Cotton seeds shall not be so imported except after fumigation with carbon bisulphide and at a prescribed port."

COTTON NOTES.

THROUGH the courtesy of the British Cotton Industry Research Association, the Secretary of the Indian Central Cotton Committee has sent the following abstracts for publication :—

PINK BOLLWORM DISTRIBUTION IN PORTO RICO.

The author reports upon a second survey made during the winter and spring of 1922-23, and conducted with a view to determining the effect of the continued presence of a few cotton plants as compared with destruction, the direction of the wind, and the climatic differences of the north and south sides of the island upon the spread of the pest. The survey has shown the entire north coast, except in a few places, to be infested by pink bollworm. It was found that normal dispersion by flight is wider from commercial plantings of cotton than from scattered wild plants, that flight is to some extent aided by winds, and is almost, if not entirely, prevented by arid or semi-arid conditions. It was found that 20 per cent. of the larvæ collected from January to April have a resting stage averaging 128 days, the maximum period being 185 and the minimum 42 days. This permits some of the moths to emerge in June, July and August rather than from February to April, the period for about 80 per cent. of them. None of the larvæ collected in September and October had a resting period, but all transformed to pupæ and adults emerged in October and November. [*Expt. Sta. Rec.*, 1924, **50**, 357 ; from *Porto Rico Dept. Agri. and Labour Sta. Circ.* 85, 1923, 3-7. G. N. WOLCOTT.]

PINK BOLLWORM CONTROL.

Experiments on the thermal death point of the pest and the temperature injurious to the germination of the cotton seed are reported upon. All seed masses must be broken up and each individual seed come in contact with the heating medium if the heat treatment is to be effective. Cotton seed uniformly heated to 145° F., with 3·5 minutes' exposure, will be rendered free of living pink bollworms. Cotton seed may be heated to 165°F. without injury to germination. Disinfecting machinery should be equipped with reliable heat control apparatus and a good recording ther-

mometer. [*Expl. Sta. Rec.*, 1924, **50**, 53; from *Texas. Dept. Agri. Bull.* 71, 1922, pp. 38. R. E. McDONALD and G. J. SCHOLL.]

CONVOLUTION OF COTTON HAIR.

A general article on the convolution of the cotton hair, its causes, and factors affecting the degree of convolution. A table is given showing the number of right- and left-handed and undeveloped convolutions for 58 divisions, each 0·63 mm. long from the tip to the base of a single Sakel cotton hair. The direction of the convolutions is discussed in connection with the striations in the hair wall, and it is shown that the direction of convolution is always the same as that of the striations in the outer layers. The author agrees with Bowman's theory of the alternations in convolution direction. [*Leipziger Monats. Text. Ind.*, 1924, 39, 284-286. A. HERZOG.]

COTTON CULTIVATION IN ASIA MINOR.

The Adana crop fell from 135,000 bales in 1914 to 14,000 in 1916 and 1917, but the 1924 crop is estimated at 160,000 bales. Under the present biennial system of rotation, cotton cultivation in the future may be expected on between two and two-and-a-half million acres each year indicating a minimum production of 800,000 bales and a maximum of 2,000,000 bales of 500 lb. In order that this result may be achieved, improved methods of cultivation, greater financial facilities to cultivators, reform in taxation and improved communications will be essential. Though the American Upland varieties are far more valuable than the native variety, giving a better yield and having a shorter period of growth, the native cottons have undeniable growing advantges under the existing systems of cultivation. The bolls of the native varieties remain fixed to the plant even when they are ripe, and do not open completely. Consequently the crop can be gathered in one picking and as labour becomes available, and there is no great risk of damage to the lint from rain and dust storms. The fact that the plant retains its bolls until all are ripened also offers greater possibilities for the invention of suitable picking machines. As less heat and water are required for the indigenous cotton, the growing of this crop is also possible at higher altitudes than would be possible with the American Upland type. The only difficulty that stands in the way of a rapid extension of Upland cotton, however, is the picking, for it appears to be well suited to the climate of the country. [*Int. Cotton Bull.*, 1924, 2, 481, 486, HUSNI SONS and CHINASSI.]

CARBOHYDRATE/NITROGEN RATIO OF COTTON PLANT.

THE onset of the flowering and fruiting stages in plant life is probably determined by the relative proportions of carbohydrates and nitrogenous substances in the tissues, or by some factor intimately connected with the carbohydrate/nitrogen ratio.

In the cotton plant the initiation of the flowering stage appears to be, within ordinary limits, independent of external conditions. Vegetative and fruiting branches are produced on a plan characteristic of each variety, and the amount of flower and boll shedding largely determines the yield. Boll shedding is due to water deficiency and to root asphyxiation, but it is in this connection that the carbohydrate/nitrogen ratio may also be important. [*Tropical Agri.*, 1925, **2**, 60. E. E. CHEESMAN.]

SPACING OF COTTON PLANTS.

A NEW method of carrying out spacing experiments is described, which consists in spacing the plants along the row in a series of gradually diminishing distances; thus, the distance between the first two plants may be 2 ft. 6 in. and that between the two last plants only $\frac{3}{8}$ in. The distance between the rows is uniform and successive experiments should be carried out in which the distance between the rows is varied. To ensure a smooth curve the mean yield of not less than 50 plants at each spacing should be determined and if possible the probable error of each series calculated. The results may be presented in a curve in which the number of plants per acre is plotted against yield per plant and against yield per acre. The curve will gradually ascend until the optimum spacing is reached, subsequently presenting little variation over a fairly wide range of spacings but ultimately descendin a spacing becomes very dense. [*Tropical Agri.*, 1925, **2**, 67. S. C. HARLAND.]

TESTING OF SEED DISINFECTANTS.

EXPERIMENTS are described on the use of the mercurial fungicides Uspulun, Germisan, Segetan-Neu, and formaldehyde in the control of smut diseases of cereals. The disadvantages of formaldehyde are that it is somewhat risky and its action is influenced greatly by the temperature of application. The mercury compounds are more powerful disinfectants but have the disadvantage that the seed requires at least half-an-hour's immersion and is difficult to dry. [*Angew. Bot.*, 1924, **6**, 463-477. G. GASSNER.]

PROGRAMME OF COTTON RESEARCH IN NORTH CAROLINA.

THE N. Carolina State College has appointed James McDowell (fifteen years ago with J. and P. Coats) to direct research along the following lines: (1) A study of the cotton hair from various areas of N. Carolina and elsewhere, with reference to bleaching, dyeing and mercerising properties. (2) Testing different yarns and cloths to determine shrinkage, strength standard, etc. (3) Testing starches and dyes. (4) Study of waste due to imperfect lint and improper use of machinery. (5) Testing uses of cotton for mechanical purposes. (6) Studying designs and finishing methods. (7) Study of mills in N. Carolina and their equipment. [*Cotton*, 1925, **89**, 346.]

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Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

THE Hon'ble Mian Sir Fazl-i-Husain, Kt., has been appointed a Temporary Member of the Council of the Governor General of India (Department of Education, Health and Lands), *vice* the Hon'ble Sir M. Habibullah Sahib Bahadur, K.C.I.E., Kt. granted leave for three months from 22nd August, 1925.

ON resumption of duty by MR. R. B. Ewbank, C.I.E., I.C.S., Deputy Secretary to the Government of India, Department of Education, Health and Lands, MR. G. S. Bajpai, C.B.E., I.C.S., has been placed on special duty.

MR. P. V. ISAAC, B.A., D.I.C., M.Sc., F.E.S., Second Entomologist (Dipterist) Agricultural Research Institute, Pusa, has been confirmed in the Indian Agricultural Service with effect from 15th June, 1925.

MR. K. MCLEAN, M.A., B.Sc., Officiating Fibre Expert to the Government of Bengal, has been appointed Assistant Director of Agriculture, Bengal, with effect from 27th May, 1925.

MR. KALIPADA MAITRA, Deputy Magistrate and Deputy Collector, has been appointed Special Water-Hyacinth Officer, Bengal, from 3rd August, 1925.

MR. R. CECIL WOOD, M.A., Principal, Agricultural College, Coimbatore, has been granted combined leave for 19 months and 6 days from 1st March, 1925. Mr. Wood has been permitted to retire on the expiry of the leave.

MR. D. A. D. AITCHISON, M.R.C.V.S., Principal, Madras Veterinary College, and Acting Chief Superintendent, Civil Veterinary Department, Madras, has been granted leave on average pay for seven months from 1st July, 1925, Mr. P. T. Saunders officiating.

MR. V. KRISHNAMURTY AYYAR, Professor of Pathology and Bacteriology, Madras Veterinary College, has been confirmed in the Indian Veterinary Service.

Mr. T. J. Hurley, M.R.C.V.S., Officiating Professor of Surgery, Madras Veterinary College, has been confirmed in the Indian Veterinary Service with effect from 1st April, 1925.

Mr. J. H. G. Jerrom, M.R.C.V.S., Superintendent, Civil Veterinary Department, Sind and Rajputana, has been granted leave on average pay for seven months from 1st April, 1926.

Mr. F. J. Plymen, A.C.G.I., Offg. Director of Agriculture, Central Provinces, has been confirmed in that appointment with effect from 10th September, 1924.

Mr. Dina Nath Mahta, B.A., F.L.S., has been appointed a temporary Botanist under the Director of Agriculture, Central Provinces, with effect from 11th July, 1925.

On return from leave Mr. T. Rennie, M.R.C.V.S., resumed his duties as Veterinary Adviser to the Government of Burma on 6th July, 1925.

Mr. A. Blake, M.R.C.V.S., relinquished charge of his duties as Special Officer Civil Veterinary Department, Burma, on 13th July, 1925.

Mr. S. R. Rippon, M.R.C.V.S., Superintendent, Civil Veterinary Department, Burma, has been placed in charge of the Veterinary School at Insein from 5th June, 1925.

The thirteenth annual meeting of the Indian Science Congress will be held in Bombay from 4th to 9th January, 1926.

His Excellency the Right Hon'ble Sir Leslie Wilson, Governor of Bombay, has consented to be the Patron of the meeting, and Mr. A. Howard, C.I.E., M.A., Director, Institute of Plant Industry, Indore, and Agricultural Adviser to States in Central India, will be the President.

The Sectional Presidents are :—

1. Agriculture . .	Mr. G. S. Henderson, N.D.A., N.D.D., Imperial Agriculturist.
2. Mathematics and Physics.	Prof. Meghnad Saha, D.Sc., Allahabad University.
3. Chemistry . . .	Prof. B. B. Dey, D.Sc., Presidency College Madras.
4. Zoology . . .	Prof. H. R. Mehra, Ph.D., Benares Hindu University.
5. Botany . . .	Rev. E. Blatter, S.J., St. Xavier's College, Bombay.
6. Geology . . .	Prof. B. Sahni, D.Sc., Lucknow University.
7. Anthropology . .	Mr. N. Subramaniya Iyer, M.A., Senior Dewan Peshkar, Travancore State.
8. Medical and Veterinary Research.	Dr. R. Row, M.D., D.Sc., Bombay.
9. Psychology . .	Prof. Haridas Bhattacharjee, M.A., Ph.D., Dacca University.

Prof. S. P. Agharkar of the Calcutta University is the General Secretary, and the Local Secretaries are Prof. G. R. Paranjpye, Royal Institute of Science, and Principal A. J. Turner, Victoria Jubilee Technical Institute, Bombay.

REVIEWS

A Text-book of General Botany for Colleges and Universities.—By RICHARD M. HOLMAN and WILFRED W. ROBBINS. Pp. x+590+374 figs. (New York: John Wiley & Sons; London: Chapman & Hall, Ltd.) Price, 20*s*. net.

THIS is a class text-book on the lines of the well known volume by Strasburger. The book is divided into two parts, Part 1 dealing with general anatomy and physiology, and Part 2 with the morphology and structure of the main divisions of the vegetable kingdom. The treatment of the structure and function of plant organs in the same chapters is an excellent feature and serves to keep ever before the student's mind the close correlation between anatomy and physiology, which generally is not sufficiently emphasized in works of this class. The second part of the book describes the morphology and life-histories of various types representative of the more important divisions and classes of plants, and concludes with a chapter on evolution and heredity. The book is well and profusely illustrated, the type clear and the order in which facts are presented logical and easy to follow. . This text-book should be popular with students of botany during their first year at a university. [F. J. F. S.]

A VERY interesting paper * on **Lathyrism** has recently been published. This disease has long been ascribed to the consumption of the chickling vetch, *Lathyrus sativus* L., vern. *khesari, teora* or *lakh*. *Khesari* is about the cheapest of the pulses and hence it forms the chief supply of nitrogenous food material required by the poorer classes. As a matter of fact, in times of food shortage, this vetch forms the principal item in their dietary for months at a time. But a free use of the mixture of seeds, which the bazar samples of *khesari* represent, is not unattended with risk. At first it brings on cramps, developing into stiffness of the legs. If the consumption is further persisted, there is an onset of paralysis of the lower extremities, and a man eating too much *khesari* for a continued length of time is likely to become a permanent cripple.

This disease has been known to prevail in Europe, Asia and Africa, the first definite mention of lathyrism in Europe being made in 1671 when the Duke of Wurtemberg issued an edict prohibiting the use of this vetch for making bread. In India the pulse has had an evil reputation, lathyrism prevailing in those parts

* "Studies on Lathyrism, I", by L. A. P. Anderson, Albert Howard and J. L. Simonsen, *Indian Journal of Medical Research*, Vol. XII, No. 4, April 1925, pp. 613-643.

of the country where the consumption of *khesari* is too high. There have been records of severe epidemics occurring when the local population has been compelled by the force of circumstances to take immoderate amounts of this cheap pulse. When it is remembered that it is chiefly the adult males, the working men in a population, chiefly cultivators, who are affected, it is apparent that the incidence of this disease, besides entailing much individual distress, involves a serious economic loss to the community.

A thorough investigation of the subject, which is being carried out by Major Anderson, Mr. Howard and Dr. Simonsen under the auspices of the Indian Research Fund Association, has already yielded valuable results. The study of the problem has been concerned with (1) the botanical investigation of the *khesari* crop and of the leguminous weeds found therein; (2) the chemistry of the seeds composing the mixed crop; (3) feeding experiments on animals with pure cultures of *khesari* and of the weeds associated with it; and (4) inoculation experiments on animals with certain chemical substances which have been isolated from the seeds of one of the weeds.

The authors are to be congratulated on their recognizing at the outset the necessity of separating, and growing in pure cultures, the various constituents of the mixture of seeds which represent the ordinary crop of *khesari*. Various other workers have studied the chemistry of the seeds and have carried out feeding experiments on animals with this pulse for the last forty years or more. But the results have been very conflicting, some investigators asserting the presence of poisonous principles which later researches have failed to confirm. In all probability, these anomalous observations are due to the use of material of uncertain botanical composition. In the present instance, however, a careful examination was first made of a large number of bazar samples of *khesari* from various places where lathyrism is common. In all about 30 samples from the Central Provinces, the Bombay Presidency, the Punjab, the United Provinces, and Bihar and Orissa were collected. These were thoroughly examined before sowing in October 1921, and all were found to be contaminated with foreign food grains and seeds of weeds, which latter were picked out and classified as far as possible. The various constituents were then sown, seed by seed, and the resulting crop kept under observation. Omitting cases of chance admixture of other food grains such as gram, wheat, etc., which are known to be wholesome, the only foreign constituent common to all the thirty samples was the narrow-leaved vetch, *Vicia sativa* L., var. *angustifolia*, vern. *akta*, the seeds of which are not unlike immature *khesari* grains in size and shape.

Considering first the pure cultures of *Lathyrus sativus* L., it soon became evident that the specimens from the various localities were not identical, and that the crop is likely to consist of a large number of elementary species. The plots fell into three main groups: (*a*) those from the black soils of the Central Provinces and Bombay, with rapidly maturing, sparse, weak, vegetative growth, very liable to insect attacks; (*b*) those from the Indo-Gangetic alluvium characterized by late but

abundant vigorous growth, resistant to disease: and (*c*) a small group from villages in the Allahabad District, intermediate in vegetative characters and disease-resistance. By the end of the third season the elementary species were separated from the heterozygotes, and a preliminary classification of the types made. The chemical investigation of the seed and the feeding trials showed that no alkaloid or other poisonous substance was present in *khesari* and that the cause of lathyrism must be sought in other directions. The time and trouble involved in isolating and classifying the elementary species of *L. sativus* has, however, not been in vain, as the series of types is proving of great interest and value in the study of adaptation to environment and of the relation between root-development and disease-resistance.

As to the leguminous weeds met with in *khesari*, it has already been mentioned that all the thirty samples collected from different parts of India contained *akta* (*Vicia sativa* L., var. *angustifolia*). Steps were taken to grow a large area of *akta* in pure culture in order to ensure a sufficient supply for the chemical and pharmacological investigations. The isolation of the numerous elementary species comprising the crop was also begun, so as to ascertain the variation in the alkaloid content.

In addition to the study of the weeds raised from the thirty samples of mixed *khesari*, the fields of cultivators in the *pergunnah* of Barail (a low-lying rice tract in the Tirhut Division in North Bihar in which *khesari* is widely cultivated and where cases of lathyrism are common) were kept under observation. Besides large quantities of *akta* there were present three other leguminous weeds, *viz.*, *misya* (*Vicia hirsuta* Koch.), *pipra* (*Lathyrus aphaca* L.) and *langra khesari* (*Lathyrus sphæricus* Retz.).

The chemical investigations demonstrated the absence of alkaloids in *khesari*. Further, *langra khesari*, in spite of its suggestive vernacular name, contained no deleterious substances, as these seeds as well as *misya* and *pipra* indicated the presence of little, if any, alkaloid bases. An examination of *akta* seeds confirmed the results of previous European work on this vetch, demonstrating the presence of vicine and vicianin. As is known, the former is a glucoside yielding on hydrolysis the base, divicine, while vicianin is a glucoside which produces hydrocyanic acid.

The animals used in the feeding experiments included ducks and monkeys. No sign of any deleterious effect resulted from the use of pure *khesari* as food for these animals even when the grain had been given in very large proportion of the dietary, in the case of ducks from 50 to 100 per cent., and in monkeys from 70 to 100 per cent., the balance when necessary being made up with normal foodstuffs. On the other hand, *akta* when fed to ducks caused death, while monkeys fed with this weed developed a characteristic train of symptoms affecting the nervous and muscular systems.

A number of experiments to test by means of animal inoculation the toxicity of vicine, divicine and vicianin, three substances isolated from *akta*, demonstrated that while vicine is probably non-toxic, the base divicine, which is a product of the

hydrolysis of vicine, gives rise to a grave disorder of the nervous system. Vicianin was found to be non-toxic.

On this last point, a few observations may perhaps be permitted. The action of vicianin when ingested is likely to be quite different from its effect as noticed in inoculation experiments. Moreover, it must be remembered that the action of cyanogenetic glucosides under digestive conditions is apt to be erratic. The poisonous action of these glucosides is due to their being hydrolysed and hydrocyanic acid being thus set free. Hydrolysis in the digestive tract is often retarded, and it has been noted that animals fed with cyanogenetic materials, even when these latter contained the co-existent glucosidoclastic enzymes, often suffered no ill effects although the amounts of available hydrocyanic acid in the food were much higher than lethal doses as determined by direct experiments with potassium cyanide. This is due to the fact that the extent and orientation of cyanogenesis in the digestive tract are influenced by the state of the digestive fluids, specially the hydrogen-ion concentration, and by the presence of other feeding stuff constituents and adjuncts. For example, it has been found that cellulose, glucose, molasses and salt, all possess an inhibitory action. It thus follows that the feeding of cyanogenetic foodstuffs is not, in every instance, visited by evil consequences. It is only when there is a special combination of suitable conditions, leading to the liberation of a sufficient amount of hydrocyanic acid, that deleterious results follow. The feeding experiments under review indicated that animals apparently throve on *akta* diet for relatively long periods of time and were subject, not to a progressive development of poisonous symptoms, but to sudden acute onslaughts of pathological conditions. It would therefore appear desirable to ascertain whether the deleterious effects are in any way connected with cyanogenesis and, if so, to what extent. In this connection reference may be made to the general belief that immunity from lathyrism is produced by the special method of cooking the grain as also by the simultaneous consumption of *mahua* (flowers of *Bassia latifolia* Roxb., which are very rich in saccharine materials).

As the authors observe, the interesting question as to the relation of human lathyrism to the disease induced in the experimental animals by feeding on *akta* must be left for further investigations. The disease in ducks in no way resembled lathyrism in man, as would be expected from such widely differing animals, but in monkeys also the syndrome was not of typical lathyrism.

While the exact nature and etiology of lathyrism can only be determined as a result of further investigation, the prevention of the disease, if it should prove to be due to contaminating weeds, appears to be a more simple matter. The growth of *khesari* in lines about a foot apart, combined with very careful weeding in the early stages, would result in a pure culture of this crop and grain free from *akta* or other weeds.

The authors are to be congratulated on their important results, demonstrating that, while *khesari* is by itself a wholesome food, ordinary bazar samples are likely

to be contaminated with foreign weeds, one of which, *akta*, is poisonous. The problem thus directly concerns a wider community than that living in the *khesari* tracts. *Akta* is widely distributed and is present as tares in other food grains too, and during the course of a study of this subject in the Chemical Laboratory of the Agricultural Research Institute, Pusa, when it was necessary to collect a large amount of *akta*, it was found to be more convenient to utilize the screenings of wheat, linseed, etc., obtained from the big grain dealers.

Besides the important discovery referred to above, the present work is expected to yield valuable ecological results which will be of practical benefit to Indian agriculture. The carrying out of the investigation gives an excellent example of team work in which the botanist at Pusa, the chemist at Dehradun and the pharmacologist at Kasauli have successfully co-operated. Accounts of further work are awaited with interest. [J. S.]

NEW BOOKS

On Agricultural and Allied Subjects

1. The Romance of the Fungus World : An account of Fungus life in its numerous guises, both real and legendary. Pp. 329+XXXI plates. (London : Chapman and Hall.) Price, 12*s.* 6*d.* net.
2. Principles and Practice of Farm Book-keeping : A Text-book for Agricultural Students. Pp. 484. (London : Gee & Co.) Price, 15*s*.
3. Farm Crops, edited by W. G. R. Paterson. Vol. I, Grain Crops (365 pp.) ; II, Root Crops (313 pp.) ; III, Pastures and Hay (314 pp.) ; IV, Miscellaneous Crops (323 pp.) (London : Gresham Publishing Co.) Price, £2 10*s.* per set.
4. Cattle-breeding : Proceedings of the Scottish Cattle-breeding Conference, edited by Dr. G. F. Finlay. (London : Oliver and Boyd.) Price, 12*s.* 6*d.* net.

The following publications have been issued by the Imperial Department of Agriculture since our last issue :—

Bulletins.

1. The Experimental Sullage Farm, Lyallpur, by P. E. Lander, M.A., D.Sc., A.I.C. (Pusa Bulletin No. 157.) Price, As. 12 or 1*s.* 3*d.*
2. Preliminary Investigations in the Bacteriology of Milk, by J. H. Walton, M.A., M.Sc. (Pusa Bulletin No. 159.) Price, As. 6 or 8*d.*

Miscellaneous.

3. The Catalogue of Indian Insects, Pt. 6. Staphylinidæ, by M. Cameron, M.B., R.N., F.E.S. Price, Rs. 1-14 or 3*s.* 3*d.*
4. The Catalogue of Indian Insects, Pt. 7. Lasiocampidæ, by T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S. Price, As. 10 or 1*s.*
5. The Catalogue of Indian Insects, Pt. 8. Amatidæ (Symtomidæ), by T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S. Price, As. 12 or 1*s.* 3*d.*
6. The Catalogue of Indian Insects, Pt. 9. Zygænidæ, by T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S. Price, Rs. 1-5 or 2*s.* 3*d.*

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EDITORIAL

THE CENTRAL CATTLE BUREAU.

The position of the cattle-breeding industry has in this country received considerable attention within recent years. The Imperial and Provincial Departments of Agriculture, as well as some of the more advanced Indian States, have drawn up schemes of improvement based on the assumption that there are too many scrub half-starved cattle in the country, and that what is wanted is an improvement in the quality of our live-stock. Improvement can be effected, it is believed, by selective breeding, cross-breeding and better feeding. The different breeds and methods of feeding in vogue in different localities are, therefore, being studied and pure-bred herds established. A foundation is thus being laid whereon the cattle industry in this country, both as regards draught and milk, will in course of time, we hope, be firmly established.

The corner-stone of the foundation required is a knowledge of the qualities of the breeds which we possess. Given this knowledge, it is possible to build up herds of pure-bred pedigreed cattle possessing the characteristics required to meet the economic needs of India. In most parts of India a dual-purpose breed should prove the most economical, and to the improvement of such breeds much attention is, therefore, being paid on many of our Government cattle-breeding farms.

The subject of cattle-breeding has been repeatedly discussed by the Board of Agriculture, and the policy recommended by that Board with respect to cattle improvement is gradually being given effect to. The Imperial Department of Agriculture has appointed a Dairy Expert and Physiological Chemist and established an Institute of Animal Husbandry and Dairying. It has started cattle-breeding operations at Karnal, and is studying various breeding and dairy problems both at that farm and at Bangalore and Wellington. Nor have the provinces and Indian States been idle. Some of them have appointed special officers for animal husbandry and dairying, as recommended by the Board of Agriculture, and are concentrating on the improvement of their best local breeds. Cattle-breeding, in short, is receiving ever-increasing attention, and the importance of the industry and the scope for its improvement in this country, where milk is a staple article of diet, and where the bullock is the motive power in general use on the farm, are beginning to be realized as never before. To foster this new interest, and to guide it, should be one of the functions of Agricultural Departments.

With a view to stimulating and to some extent co-ordinating the efforts being made towards cattle improvement on farms controlled by the Imperial and Provincial Departments of Agriculture, Indian States and private individuals, the Government of India have decided to give effect to the recommendations made by the Board of Agriculture in 1924 and to establish a Central Bureau of Animal Husbandry. The control of this Bureau will be vested in the Imperial Dairy Expert and its head-

quarters will be his office. The main duties of this Bureau, to commence with, will be :—

(1) To collect and disseminate information concerning cattle-breeding and allied subjects,
(2) To assist in the disposal of surplus pedigreed stock available on Government cattle-breeding farms,
(3) To standardize breeding records and methods of milk recording,
(4) To maintain general herd books of breeds, or of milch cattle as distinct from specific breeds found in more than one province or State,
(5) To encourage the use of pedigreed stock,
(6) To keep the officers in charge of cattle-breeding in provinces and Indian States in touch with each other.

Breed records should be maintained by an All-India authority as herds of the same breed are found in different provinces and Indian States. There is, for example, a number of herds of Sindhi cattle good enough to be registered in a herd book, in Sind, Mysore, the United Provinces, Bengal, Burma, Madras, the Central Indian States, the Punjab, Travancore and Baluchistan ; and no Cattle Board having jurisdiction in one of these provinces or States only could conveniently keep the necessary records for all these Sindhi herds. To avoid complications, it is very necessary that a serial number should be given from the very beginning for each animal registered, and that this number should not in future years be duplicated. In the case of a milch breed in particular, the actual recording of the milk yields of each animal and the progeny thereof over the whole country should be done by a central authority which is in a position to certify as to the correctness of the yields of the animals recorded.

In parts of Europe such records are kept by breed societies subsidized by Government in most cases. In the United States, Canada, England, Scotland and Ireland, milk records are certified by special societies subsidized by the Governments concerned. Those societies are formed and largely controlled by Milking-breed Societies.

India will never take the place which she ought to take, as the premier breeder of the tropical draught and milch cattle, until she has correct breed records for the best types of each breed. As the people of this country interested in cattle-breeding are not yet sufficiently educated or public-spirited to form and work breed-societies which would give reliable pedigree and milch and draught record certificates, such records will, for the present at least, have to be maintained by a central department of Government. The Government of India hope that Agricultural Departments, as well as private individuals interested in the cattle industry in this country, will co-operate with the Imperial Dairy Expert in his efforts to make the Central Cattle Bureau of real value, and to lay the foundation of an organization which may one day provide accurate information with respect to the good qualities of Indian cattle—the finest in the world for tropical climates.

Mr. S MILLIGAN, M.A., B.Sc

ORIGINAL ARTICLES

MR. SAMUEL MILLIGAN, M.A., B.Sc.

AN APPRECIATION.

As a result of the retirement of Mr. S. Milligan, M.A., B.Sc., to take up an appointment under the Empire Cotton Growing Corporation, the Indian Agricultural Service lost one of its most eminent members. Mr. Milligan was one of the small batch of experts recruited by the Government of India shortly after that great Viceroy, the late Lord Curzon, inaugurated his policy of rural development in this country. Reared on the land and in close touch from his infancy with the advanced methods of farming for which his native county of Dumfries in the South of Scotland is famous, he was a born agriculturist in the true sense of the term. Like many of the sons of our leading Scottish farmers, however, he was still not satisfied that he was sufficiently well equipped for the vocation of farming. He yearned for that more scientific knowledge of his calling, and on leaving school proceeded to Edinburgh University where he distinguished himself both in arts and science. Thus equipped with a solid foundation of scientific lore, he took up farming on a large scale, and for five years was one of the leading lights in the farming community of his native county.

In 1905, he was selected for a post in the Indian Agricultural Service. In October of that year he proceeded to India and was posted to the Punjab where he made his mark as a Deputy Director of Agriculture. The well-devised policy of agricultural development which has added so materially to the wealth and welfare of the Punjab cultivator was due, in no small measure, to his initiative. In 1912, he was promoted to the post of Imperial Agriculturist at Pusa where he did valuable work in raising the general standard of intensive cultivation, cattle-breeding and dairying on that Estate. In 1916, he was given the appointment of Director of Agriculture in Bengal —an appointment which he filled with credit to himself and to his Service. He succeeded Mr. (now Sir) James Mackenna, as Agricultural Adviser to the Government of India in 1920. During his period of office as Agricultural Adviser he proved an able administrator and a wise counsellor. His sound commonsense, outstanding personality, tact and friendly disposition gained for him the confidence of his colleagues in the department. He left India to take up a very important appointment in another part of the Empire, and I notice that in the report of the Administrative Council of the Empire Cotton Growing Corporation his present employers have had occasion to congratulate him both on the results he has already attained and on the organization he is building up for future development.

His retirement from the Indian Agricultural Service was a distinct loss to India. As one of the pioneers in rural development. he helped very materially in laying well and wisely the foundations of scientific agriculture and in developing India's premier industry.

D. CLOUSTON.

SOME RECENT ADVANCES IN THE PROTECTION OF CATTLE AND OTHER ANIMALS AGAINST DISEASE.

[PAPERS FROM THE IMPERIAL INSTITUTE OF VETERINARY RESEARCH, MUKTESAR. (*Director*, MR. J. T. EDWARDS; *Secretary for Publications*, MR. S. K. SEN.)]

III

RINDERPEST.

Considerations of space available in this issue of the *Journal* preclude the insertion of a detailed description of this formidable cattle disease, and so this article deals mainly with the precise methods within the reach of all cattle-owners in India for combating the scourge by the adoption of certain preventive measures. Rinderpest, or cattle plague, exacts an annual toll upon the cattle population of India far exceeding that of any other disease. It varies considerably in severity from year to year. For a period of about three years or so it would appear to gain gradually in intensity, spreading rapidly, and carrying away before it large numbers of cattle in the affected areas. Then, for a similar period, it would seem to abate, with the result that it shows a greatly diminished tendency to spread, and the animals that become affected with it recover in very considerable numbers.

This phenomenon of an alteration in intensity and mildness in the disease may be understood in the light of what has been stated concerning contagious disease in general in the introductory article to this series of papers. Rinderpest, like the other contagious diseases, is caused by a living parasite, and this parasite is of such small size that it cannot be readily detected even with the highest powers of the microscope. Much work has been done upon its nature, and researches have been carried out upon a large scale in this direction at Muktesar during the last three years. It would appear to be an extremely minute fragile organism of the spirillary class to which the property of producing violent disease in cattle seems to be one readily lost when its propagation takes place elsewhere than in the animal body. Invasion with this virulent parasite, that is, with the disease, causes in a susceptible ox after a so-called incubation period of a few days (usually two or three in very susceptible animals, but may be four to six in relatively resistant ones) a high fever, and with the onset of fever the animal shows signs of dullness and loss of appetite. Small blebs (vesicles) then appear on the lining of the gums and tongue, which later burst, leaving small ulcers. Disturbances to the alimentary tract are next seen, and the affected animal shows first loose fæces, and then diarrhœa, which may become so severe that the fæces are almost watery in consistence. Death then occurs usually in such severely affected animals, and the time of death may be from ten days to

three weeks or later after infection. A curious manifestation is sometimes observed in that animals which seem to be well on the road to recovery from the rinderpest symptoms have a relapse of grave intestinal trouble, with very soft or watery fæces, sometimes containing small clots of blood, and die. Death in such cases is not due to rinderpest itself, but to the depression in the lining of the bowel caused by the attack of rinderpest permitting a port of entry for destructive invasion to certain minute animal parasites (known as coccidia) normally subsisting in a state of latent or subdued activity in the bowel of cattle, it would seem, usually in India.

The mortality from rinderpest, however, varies greatly, as has been said, in different years, and also among different breeds or kinds of cattle. Cattle imported from Europe are notoriously susceptible to rinderpest, and when they contract the disease nearly always suffer from the acute type and almost invariably succumb. The cattle of the Himalayan foothills display again a high susceptibility towards the disease, though not so high usually as that of European cattle. The cattle living on the plains of India are, on the other hand, relatively resistant, although the different breeds and the animals of different localities vary somewhat among themselves in this quality of susceptibility. An outbreak that would kill off all European cattle would probably destroy only thirty per cent. or less of Indian plains cattle. The explanation of this difference in susceptibility would seem to be that the cattle of Europe, for example, and especially the cattle of Western Europe, have for many generations not been confronted with the imminence of invasion with the disease, while on the plains of India it is an ever recurring menace to the existence of the species, and with each outbreak it is the more resistant cattle that survive. Hence, in the course of time, it is reasonable to assume that the races of cattle represented by the ordinary village cattle of India have been evolved, by a process of natural selection, from ancestors that have displayed a relatively high resistance to rinderpest, while, on the other hand, the existing races of European cattle need not necessarily represent progeny derived from ancestors possessing these traits. Again, in hilly or mountainous tracts, the natural topography of the areas acts as barrier against the ready spread of the disease. Rinderpest is spread usually through the medium of the excreta (urine, fæces, and nasal discharges) of cattle at the height of an attack of the disease, and it is known that the "virus" soon perishes when exposed to natural agencies, such as dilution in liquids, sunlight, and desiccation. In fact, fairly recent researches show that within 48 hours after discharge these excreta are usually innocuous; the "virus" of rinderpest is therefore an organism that becomes rapidly inert, and is not a highly resistant individual like the spore of the anthrax bacillus, which may survive many years in infected soil. Infection in rinderpest is thus carried ordinarily by an infected animal, and where intercourse among animals is difficult the tendency towards the natural spread of rinderpest is limited, and the breeds of cattle resident in such areas are of the kind that are not normally exposed to frequent outbreaks of rinderpest in the course of their evolution.

The theory of the "waves" of intensity in rinderpest would seem capable of explanation in a similar manner. After the onset of a "wave" of rinderpest the disease spreads with increasing intensity until the virus eventually finds that the amount of susceptible "soil", remaining upon which it can become readily implanted, becomes more and more rare. The virus itself thus loses to a considerable degree its properties of penetrating the animal body, and it is not until there is available in abundance a new susceptible "soil," represented by the cattle progeny that have grown up in the interval, that the "virus" finds a medium at hand for its ready propagation and, concomitantly, progressive exaltation of its disease-producing properties.

Since October 1924 rinderpest has been increasing steadily in intensity over India after a period of relative abatement in severity extending over about three years nearly. As has been stated, there is no known cure for the disease, once it has attacked an animal. In countries where measures of control can be applied by a well and strongly organized State veterinary service, rinderpest is "stamped out" by the destruction of infected animals and prohibition of importation of animals from infected countries. In fact, a distinguished veterinary writer commenting upon the outbreak that occurred in Belgium in 1920, stated that there was hardly any danger of the disease ever gaining a footing again in Western Europe, for the veterinary police measures applicable for the prohibition of movement in infected and suspected areas was sufficient to prevent the spread of the infection from an original outbreak. Conditions in India have not yet reached this much desired state, and it is most improbable that an adequate veterinary organization for the proper control of the formidable scourge in the manner of Western Europe will be forthcoming for many years. One must therefore look to other weapons for combating the disease, and, fortunately, there are means now at hand which are amply sufficient to enable any intelligent cattle-owner to place his stock completely out of reach of danger. The methods of protection are detailed in the technical bulletins issued by the Muktesar Institute reprinted below.

(a) Active immunization of cattle, by means of the "serum simultaneous", or "serum virus" method.

1. Principles.

Cattle that recover from rinderpest are subsequently immune towards the disease, apparently for the rest of their natural lives.

They develop this immunity in virtue of the well known fact that their tissues respond by elaborating certain properties (or "antibodies") which can readily be detected in their blood, or blood serum, a short time after recovery.

The serum of such a recovered animal, containing the so-called antibodies, can be used to protect susceptible cattle, and if an adequate dose of the serum is injected under the skin of a susceptible animal it is protected with certainty and immediately

against attack, but the immunity thereby conferred lasts only a short while, about 9 days. In the scene of persisting infection the susceptible animal ought to be injected again with a sufficient dose of serum every 9 days while the danger of contracting the disease remains. This kind of immunity is said to be a "passive" one, inasmuch as the animal inoculated plays merely a "passive" part in the process; it is protected by means of antibodies transported mechanically, or artificially, into its system from the body fluids of another animal, namely, one which has taken the "active" part in manufacturing them. The antibodies do not persist in the system of the passively immunized animal but are gradually excreted in the urine and to some extent along other channels in the same manner as drugs and other substances injected into the animal are eliminated.

In the method of active immunization, on the other hand, the treated animal is caused to manufacture its own antibodies in exactly the same manner as if it were made to pass through the natural attack of the disease, and the immunity developed subsequently is a lifelong one, that is, the animal never runs any risk of contracting rinderpest again so long as it lives. The only difference between the natural attack and the process of active immunization is that whereas in the former the attack very often ends fatally, in the latter operation the severity of the attack is artificially controlled, and when the control is at its best the animal never shows any outward signs whatever of bodily disturbance.

The operation is very simply carried out in practice: the susceptible animal is inoculated subcutaneously with a certain dose of serum, estimated to be more than adequate to protect it against the development of an attack of clinical rinderpest, and, simultaneously, it is also inoculated with a small dose of virulent blood, that is, blood withdrawn from an animal at the height of an attack of rinderpest, during the most severe febrile period of the disease. If the animal were inoculated with the virulent blood alone it would contract a severe, probably fatal, form of the disease. The protection conferred upon the animal immediately by the serum, however, keeps the attack in check, to such an extent that no outward sign of disease is seen; usually there is a mild attack of fever, but very often no distinct rise of temperature can be recorded by means of the thermometer after the lapse of a few days following upon the inoculation when one ordinarily expects to find a rather sharp rise of temperature in rinderpest.

The same result, in principle, is achieved when a susceptible animal protected by serum is placed in intimate contact with naturally affected cattle. It is then likely that the animal will contract infection, in the natural manner, from the affected cattle, but the attack of disease it suffers will be suppressed by the resistance conferred upon it at the time by the serum. (See, later, the instructions for the "*'Passive' inoculation of cattle, by means of the 'serum alone' method,*" in the scene of outbreaks.) This consummation is not acquired, however, with the same degree of certainty in this manner as it is by the injection of so-called virulent blood, obtained from an animal at the height of an attack of the disease.

2. Method of Operation.

(A) Care, choice and retention of animal :—

While undergoing the process of active immunization against rinderpest the animal ought to be fed on a good diet, of a somewhat laxative character. Care should be taken specially that it is not liable to produce a constipating effect, for rinderpest is known to cause profound disturbance of the alimentary tract. It should be light rather than heavy in amount. If the animal should exhibit diminished appetite it ought to be given soft mashes or drenched very carefully with oatmeal gruel.

Cows in an advanced stage of pregnancy should not be inoculated.

Young weak calves should not be inoculated, but calves that are a few weeks old and in strong condition may be done without additional risk, and it is economically sound to practise the operation upon cattle at as early a stage during their existence as possible. Careful experiments have shown that very young strong calves can be immunized with impunity. Calves are also more resistant than adult cattle are towards the complicating effects of "redwater" (see later).

Animals that are very weak or debilitated from any cause should not be inoculated.

It has been recommended in the past that the inoculations should only be undertaken on the plains during the cooler parts of the year. Careful experiment at Muktesar have recently failed to demonstrate any differences in the efficacy of a potent serum when it is employed for the process during the hottest months on the plains and simultaneously in the cool climate of the hills.

Great care ought to be taken, however, to prevent overcrowding of the animals or placing them in close ill-ventilated buildings, particularly after they have been accustomed to living in the open.

As rinderpest is a serious contagious disease great care should be taken to exclude all possibility of spreading the infection from the animals undergoing inoculation to susceptible animals that are maintained on the establishment and are not being submitted to the process. It is believed that in natural circumstances animals contract the disease by the ingestion of foodstuff contaminated with excreta and nasal discharges of affected animals. It is known that the discharges usually become harmless after they have been in contact with the ground for over two days. Hence, the virus is readily destroyed by natural agencies, particularly by the action of sunlight, dilution, and desiccation. This knowledge will indicate the extent of the precautions that should be taken to exclude spread of infection : the inoculated animals should be kept in a separate building or enclosure and all access between it and the place where the uninoculated animals are kept should be rigidly closed and guarded. The inoculated animals should be under the care of separate attendants, who should not be allowed to come into contact with the uninoculated animals, either directly, or indirectly, by communication with their attendants, fodder and

sundry articles used in their management. A responsible individual should always remain on the establishment to see that these precautions are duly observed. It is also a sound precaution to place at the entrance to the building or enclosure where the inoculated animals are kept a sufficient number of smocks for use by the attendants while they are at work with the animals and then to be taken off and left at the entrance when they leave their work. If the attendants wear boots these might be changed at the entrance; if they are barefooted a shallow pail of disinfectant fluid should be left at the entrance in which they should bathe their feet on leaving. It ought also to be remembered that traffic by all animals from the inoculation enclosure must be prohibited. These precautions are to a considerable extent unnecessary if the inoculated animals are kept at a long distance, about 800 yards or more, from the uninoculated animals. Again, if the process is repeated on an establishment every year the animals that are awaiting immunization can be inoculated without taking any precautions against the spread of disease to the other animals, which are already immune.

(B) Materials for inoculation :—

(1) Serum for the active immunization of cattle against rinderpest by the serum simultaneous method.
(2) Virulent blood.
(3) Hypodermic syringes.
(4) Clinical thermometers.
(5) Veterinary officers in charge of the inoculations should also have in readiness a suitable microscope with a high power oil-immersion lens for the examination of stained blood films from any cattle that may show suspicious symptoms of "redwater." The staining fluid should be one of the Romanowsky stains (Leishman, Giemsa, Wright, Jenner). These appliances are useful adjuncts in case any of the cattle show signs of infection with *Piroplasma bigeminum* during the course of the reaction, when the complicating infection may be checked by a timely injection of *trypanblau*. A microscope, however, is not an indispensable necessity, for, as will be stated later, experience has shown that it is a wise plan to assume any considerable rise of temperature between the 6th and 12th days to be due to a piroplasmosis complication, and to treat any animal showing such a rise of temperature by injecting it at once with *trypanblau*.

(1) Serum for the active immunization of cattle against rinderpest by the serum simultaneous method.

The serum required for the inoculations should be specially indented for from the laboratory a short time before the anticipated date of the inoculations, and the request for the serum should be made in the above precise terms. Old stocks that

have remained over from a previous season should not be used. All serum issued from the Muktesar laboratory is tested before issue and is potent at the dosage stipulated on the label on the bottle, but all serum is not suitable for the process of active immunization.

The serum to be used for active immunization is a special serum, from the first bleedings of buffaloes or hill bulls and one which has also been specially tested and found to " block out " a thermal reaction at the higher doses employed in the routine tests (90 c. c. per 600 lb. body weight of hill bulls). This serum is issued in bottles with special white labels, on which the words " This serum may be used for active immunization against rinderpest " are printed ; the brew number is also written on the label.

When officers contemplate undertaking the task of immunizing a number of cattle by the method they may obtain guidance if they submit a list to the laboratory indicating the number of cattle they desire to immunize, together with the breeds of the cattle and the number of the cattle comprising each breed if there should exist more than one breed in the herd. The approximate body weights and ages of the animals should also be given.

As the various breeds of cattle exhibit marked differences in susceptibility towards rinderpest, the dosages of serum to be administered for adequate protection must be carefully calculated. The following is a list which indicates roughly the quant'ties of serum that ought to be inoculated into different breeds and cross-breeds of cattle, according to the experience of this laboratory, and based upon the knowledge gained as to their relative susceptibility :—

	Doses of serum in cubic centimetres per 600 lb. body weight
Class of animals	
Ayrshire cattle	250—300
Holstein cattle	250 300
7/8 European bred cattle	220- 240
3/4 " " "	175—200
1/2 " " "	125—150
1/4 " " "	100—125
1/8 " " "	80-- 100
Country breeds	
Scindi breed	60
Sahiwal breed	40
Hariana breed	30
Buffaloes	
Delhi	60

It will be noticed that European-bred cattle are recommended rather massive doses of serum, on account of their extremely high susceptibility, whilst some relatively insusceptible Indian breeds are administered small amounts. In the case of any herd of cattle not mentioned in the above list, the dosages will be estimated from the known mortality rates among affected animals in the scene of numerous natural outbreaks.

When information has been obtained as required above, the quantities of the particular brew or brews of serum indicated will be despatched. Indenting officers should state on their indent forms the quantities of serum which they require, calculated according to the above indications in cubic centimetres, and state separately the amounts they require for (*a*) pure European breeds, (*b*) cross country breeds, (*c*) country breeds, and (*d*) buffaloes. The reason for stating the quantities required for the various classes separately is that endeavours are made to manufacture from time to time "brews" of serum of specially high potency for the more susceptible cattle. In complying with the indent the Institute will indicate the brews that are to be used on the several classes.

(2) *Virulent blood.*

Blood taken from an animal during the height of a rinderpest reaction is virulent in extremely small quantities (1/1000 c.c. or even less). The dose to be injected need not be gauged with any pretence at accuracy, and $\frac{1}{2}$ to 1 c.c. of the virulent blood is usually administered subcutaneously in this process ($\frac{1}{2}$ c.c. for the most susceptible, and 1 c.c. for the least susceptible animals).

The blood unfortunately soon loses its virulence. Kept sterile in small quantities exposed to air at body temperature it has usually completely lost its virulence in 3 days; if kept sterile in sealed glass containers or under a layer of liquid paraffin it retains its virulence at this temperature for 10 days or even longer. At lower temperatures the duration of its virulence is much prolonged, and if the blood must be kept an appreciable time at its destination it ought to be stored on ice.

Arrangements are now being made at the laboratory for the despatch by post to field workers of virulent rinderpest blood for this method of immunization. Notice must be received (preferably telegraphically) at the laboratory of a request at least six days prior to the date when the blood must be forwarded. The virulent blood is transported in a sterile condition, in sterile air-tight bottles, and in this form it has been shown to retain its virulence for over 9 days when exposed to "plains" hot weather conditions. The blood, however, must be used for inoculation immediately it arrives at its destination, and in case it may have lost its virulence in any one bottle it is advisable to mix the contents of all the bottles prior to use and inject 1 c. c. at least of the mixed sample into each animal to be immunized, simultaneously with the serum. It is well to inoculate one or two susceptible animals of small value

with the blood without serum in order to obtain a guide as to the degree to which it has retained its virulence. If these animals react normally, from the 3rd to the 6th day after inoculation, some of their blood may be withdrawn, defibrinated, and injected at the rate of 5 c.c. per dose into the animals undergoing immunization, in order to make sure that all the animals become infected while under the influence of the serum. Otherwise, if it is not possible to inoculate animals on the spot for the production of a second dose of virus, the laboratory must be informed, and a second consignment of virulent blood will then be despatched in sufficient amount to inoculate the animals undergoing immunization a second time at the rate of about 5 c.c. for each animal.

The second inoculation with blood, which is unnecessary if the animals show a reaction to the first inoculation, should be performed in from 5 to 8 days after the original simultaneous injection with serum and blood.

Experience during the cold weather 1924-25 proved that this method of despatching the virus was completely satisfactory; animals were injected quite successfully in Southern India with material received by post six days after it had been withdrawn and specially bottled at the laboratory.

(3) *Hypodermic syringes.*

At least two syringes are necessary, namely, (*a*) a small syringe, for the inoculation of the virulent blood (a convenient syringe is a "Record" syringe of 1 c.c. capacity), (*b*) a larger syringe for the inoculation of the serum. A "Record" syringe of about 50 c.c. capacity is a convenient large syringe: when not in use the metal piston should be kept detached and smeared with vaseline. Another convenient type of large syringe is the so-called Stockman syringe, obtainable from Messrs. Baird and Tatlock, Ltd., Cross Street, Hatton Garden, London, E. C., as the contents of the barrel can be injected and the barrel then refilled without withdrawing the hypodermic needle, or withdrawing the nozzle of the syringe from the needle. This is a consideration when large quantities of serum have to be injected into any one animal. These syringes are usually obtained with barrels of 50 c.c. capacity, but larger sizes can also be obtained from the firm.

Before use these syringes are cleaned and sterilized by boiling for 10 minutes. (The component parts of the "Record" syringe are detached before they are placed in the water bath for boiling, and it is best to secure the parts in the places allotted for them in their metal case during boiling).

The serum is injected at any site where there is much loose subcutaneous connective tissue, such as in front of the shoulder joint or behind the elbow, and when a large quantity has to be given it is well to inject it into more than one site to ensure rapid absorption. The virulent blood may be injected at any other convenient site. The seats of injection are swabbed with a weak disinfectant fluid, such as 2

per cent. cresol, prior to the injection of the fluids. If the hair over the seats of injection is long, it should be clipped beforehand by means of a pair of scissors or hand clippers.

3. Variation in mode of procedure in different circumstances.

If the virulent blood reaches the user in a certainly highly virulent condition the procedure is extremely simple: the serum and virulent blood are injected simultaneously in the quantities and in the manner indicated above, and no further inoculation is necessary. If there is a slight suspicion that the blood was not virulent a second inoculation with blood again received from the laboratory, at the rate of about 5 c.c. per animal, ought to be performed between the 5th and 8th day after the first inoculation, but not later.

If, however, there is considerable doubt as to the probability of the blood proving virulent upon all the cattle in the small quantities recommended, then the user has to take steps to manufacture his own virulent blood on the spot. For this purpose, he will need to take one or two susceptible animals, preferably calves, of small value, and inoculate them with a considerable quantity (20 to 50 c.c.) of blood received from this laboratory. The temperatures of these calves are taken morning and evening after the inoculation, and when they show a distinct rise of temperature, four, five or six days afterwards, and small vesicles appear on the buccal mucous membrane, the required quantity of blood is withdrawn into a vessel from their jugular vein and rapidly defibrinated by shaking the vessel vigorously for several minutes to prevent clotting. It is not necessary to wait until vesicles appear before taking virulent blood, for experience has shown that the blood is often more virulent at the height of the febrile reaction, prior to the appearance of local lesions in the mouth. The vessel should be a boiled glass flask or large bottle specially prepared for the defibrinating process by placing inside it a tangled coil of metallic wire. The vessel is boiled and allowed to cool just before use. The defibrinated blood thus withdrawn is used as the virulent blood for injection into the animal to be immunized.

Although the use of virus producers (so-called " controls ") locally ensures that a product of assured virulence is obtained, the method may be regarded as very objectionable by officers in some localities where animals may not be available for this purpose, or the procedure may be resented on æsthetic grounds.

All intending employers of this process are therefore enjoined to obtain samples of virulent blood from this laboratory and ascertain by a preliminary test on a few animals which they may be able to procure whether or not they can receive the virus soon enough by the ordinary rail or postal facilities communicating them to the laboratory, so that, in all their subsequent operations in that locality, they can rely upon getting the blood sufficiently quickly to be used direct upon the animals they have awaiting immunization.

They may find by adopting these steps that the procedure of active immunization can always be reduced to a very simple matter for them.

4. Disturbances and complications that may appear in the inoculated animals.

If the serum is of sufficient potency and the virulent blood injected infective, the disturbances are extremely slight, often scarcely observable, but one may expect a distinct rise of temperature to occur in the form of a gradually ascending and descending curve between the 4th and 9th days. The reaction in an animal under serum protection is often noticeably delayed. A stronger attack is indicated if the animal refuses food, and discharges from the eyes and nose, and, in a severe attack, lesions are seen inside the mouth (vesicles and ulcers) and pronounced diarrhœa. The severe disturbances show that the serum injected was insufficient in quantity or not of the proper strength, and ought not to occur if attention has been paid to these points.

Subsequent to the inoculation the animal may exhibit, however, disturbing symptoms which are not in reality those of rinderpest itself, but usually those of—

(i) Piroplasmosis, or

(ii) Coccidiosis.

(*i*) *Piroplasmosis.* The piroplasmoses are diseases caused by the invasion of the red blood cells with numerous minute animal parasites (piroplasms) which rather closely resemble the malarial parasites of man. In natural circumstances they are transmitted from animal to animal by the bites of ticks, but they can also be transmitted artificially from an infected animal, or a "carrier" of the piroplasms, to a susceptible healthy animal. In this manner they may be injected inadvertently into the inoculated cattle with the virulent blood. These parasites which produce severe attacks of disease, the so-called tropical redwater, and are known as *Piroplasma bigeminum,* cause a sharp rise of temperature (3° or 4°F. or more) between the 6th and the 10th day after inoculation, and sometimes a day or two later, and frequently after the fever has been in progress for a very short time the urine of the animal becomes coloured red, from the presence of destroyed blood excreted by the kidneys; sometimes, however, the animals die suddenly without passing red-tinged urine. The piroplasms are relatively large bodies, which may be found at times inside the blood cells in rather a typical form, resembling two pears meeting towards their narrow ends with their bodies set at a somewhat acute angle. The disease caused by these piroplasms can be treated by injecting the animal under the skin, directly the infection is detected, with 100 c.c. of a one per cent. solution of *trypanblau,* which is freshly prepared by boiling one grm. of the powder in 100 c.c. of water and allowing the solution to cool until it reaches body temperature. If the symptoms are very serious, the solution ought to be injected intravenously and the

fluid filtered through blotting paper prior to use. The injection of *trypanblau* usually produces a sharp drop in the temperature of the animals suffering from this type of infection ; if the fall in temperature does not occur in 6 hours or the constitutional symptoms become serious the injection should be repeated, now intravenously. It is strongly advised, therefore, that careful watch should be kept upon the temperature of the animal during the period when the symptoms of redwater are likely to appear, particularly when the animal is an imported one, and if there occurs a suspicious rise *trypanblau* should be injected immediately.

In many localities all the cattle become infected--naturally, while they are young, by the bites of ticks, with this form of piroplasm. Young cattle possess a high degree of resistance and recover readily, but they always harbour small numbers of these parasites in a dormant state in their systems afterwards throughout life. During a mild attack of rinderpest, the parasites may be roused again from their dormant state owing to the somewhat depressed condition of the animal's body and invade the system once more in very large numbers. This awakening of the parasites may take place at any time after the inoculation, and the disease then seen is not due to any piroplasms that may have been present in the virulent blood. The treatment is the same as advised above.

There is an advantage in using "controls" for the production of virulent blood in the locality where the animals are situated that are to be immunized, inasmuch as the blood will generally be taken from them for inoculation before the infection due to the piroplasms that may have been present in the blood received from the laboratory has had time to develop.

During the progress of the reaction following upon immunization large numbers of very minute piroplasms may be seen sometimes in the blood, and these are usually comma-shaped, rod-shaped, or somewhat oval. They are known as *Theileria mutans* and do not appear to cause much harm as a rule.

(*ii*) *Coccidiosis.* This is a prevalent disease condition affecting the hinder part of the digestive tract of cattle caused by minute egg-shaped or ball-shaped animal parasites (protozoa) known as coccidia, which can be detected by examining a fresh film of fæces or, preferably, the mucous constituents of the fæces of affected animals. In the gut wall they undergo complex development and assume many varied shapes. In many localities most or all of the cattle carry these parasites in their bowels to a slight extent. These cattle become infected while they are young, but if they manage to survive until they are older they contrive to tolerate the presence of the parasites very well. However, if the powers of resistance of an affected animal become depressed, as during a slight attack of rinderpest, from which it would otherwise recover, the parasites again multiply rapidly and cause serious changes in the lining of the bowel and clinical symptoms of dysentery. A few days after the danger of rinderpest appears to have passed away, the animal may thus commence to strain and groan as if there were pain in its abdomen, small masses of pure blood clots are seen in the fæces, the fæces become soft, covered

with slime and, finally, in severe attacks, watery in consistence. An animal undergoing convalescence after an attack of rinderpest may thus succumb to this secondary infection. While suffering from this condition the animal should be given gruel, as a drench, if it refuses to take its ordinary food, in order to strengthen its powers of resistance.

The onset of this complication is prevented by administering the anti-rinderpest serum in the serum simultaneous method of immunization in sufficient excess to " block out " all clinical disturbances due to rinderpest so as to obviate the selective depression of the gut wall that takes place in the disease.

Sometimes cattle may show an infection with trypanosomes in their blood brought about in much the same manner as has been described in the case of the piroplasms. These trypanosomes are identical in appearance with those of surra. As a rule they do not cause much disturbance in cattle in India, but in buffaloes their effects are much more severe. They can be caused to disappear by the injection of a solution of tartar emetic intravenously, at the rate of 5 c.c. of a 3 per cent. solution per 100 lb. body weight, and the injection should be repeated in the event of a relapse.

These complications are those most likely to occur during the course of active immunization against rinderpest, but the loss due to them is extremely small when it is calculated among a very large number of cattle inoculated properly by the serum simultaneous method.

(*b*) Passive immunization of cattle, by means of the " serum alone " method.

This is the method now commonly employed by provincial veterinary authorities in India for combating outbreaks of rinderpest. Its limitations have been explained in describing the principles of active immunization against rinderpest. Nevertheless, in the face of an actual outbreak of the disease it is the method that should be adopted *immediately* the disease is detected in a herd or locality, for, following inoculation with the serum alone, animals that have not already contracted infection are protected surely and at once against fatal attack. The protection conferred by the serum does not remain efficacious after the lapse of a fortnight, but if steps are taken to mix the inoculated animals while they are under the serum protection with those suffering from the disease in the vicinity it is probable that they will pass through a very mild or suppressed attack, and then on recovery acquire life-long immunity. It is of importance in the scene of an outbreak to inoculate *all* of the cattle exposed to danger, and not only a portion of the cattle. Otherwise, the uninoculated cattle may contract the disease, and keep it alive until the effects of the serum protection upon the inoculated animals have passed away. It has been explained earlier in this paper that a factor of the greatest importance in the control of rinderpest is to bring all movement of cattle within an area that is infected, or

liable to become infected; to an absolute standstill, for infection is transmitted mainly by the movement of animals harbouring the disease. Concurrently with the application of serum protection in the scene of an outbreak it is therefore of prime necessity to adopt measures of veterinary police control, comprising (i) mixing of inoculated animals in proximity to infection with the naturally affected cattle, (ii) complete restriction of movement within a wide radius of the disease centre, until the disease has disappeared.

Anti-rinderpest serum is manufactured in very large quantities at the Muktesar Institute for issue to provincial veterinary authorities, and the following directions are issued with the consignments of serum :—

(N. B.—*No virulent blood to be used.*)

1. The "serum alone" method is to be used only in actual outbreaks of rinderpest. It serves to protect animals from contracting the disease and thereby curtails the spread of the infection. The immunity conferred by a single dose of serum is of short duration. Consequently, if cattle are subjected to infection for a longer period they should be reinoculated. (See above instructions on the "Active immunization of cattle against rinderpest".)

2. The serum is injected subcutaneously in the region of the shoulder, and, for this purpose, the hair should be clipped over a small area about two inches in diameter, and the part washed with a 5 per cent. carbolic solution before introducing the needle of the syringe. After injecting the fluid withdraw the needle placing one finger or thumb over the small swelling made by the injected serum in order to diffuse the fluid downwards into the surrounding tissues before letting the animal free.

After inoculation with serum alone, all the animals should be turned out together with the infected herd in order that an opportunity of contracting natural infection and a longer immunity may be given. (See above instructions.)

3. *Standardized dose of serum :—*

For hill cattle, per 600 lb. body weight........90 c.c.

4. Each brew of serum is tested before issue on cattle of hill breed, which are most susceptible to rinderpest.

The protective standard dose is the amount of serum necessary to protect a hill bull weighing 600 lb. against a simultaneous inoculation of a lethal dose of virulent blood.

No brew of serum is issued which does not protect at a dose of 90 c.c. per 600 lb. body weight of hill cattle.

5. *For plains cattle the dose of serum cannot be fixed owing to the varying susceptibility of cattle throughout India.*

A dose of 5 c.c. per 600 lb. body weight has been found sufficient to protect village cattle of the lowest susceptibility.

Doses from 10 c.c. upwards are required according to the susceptibility of the cattle as shown by the severity of the outbreak. It remains the duty of the veterinary officers in charge of the operations to determine the dose of serum necessary.

6. The following instructions have been formulated for guidance in regulating the dose of serum :—

(i) For plains cattle doses of 10 to 30 c.c. per 600 lb. body weight should be used under the following circumstances :—

(a) When from observation of the mortality among non-treated animals there is evidence of a high degree of susceptibility.

(*b*) When the outbreak is wide-spread and it is probable that animals will be exposed to infection for a long period.

(*c*) For cattle, such as conservancy bullocks, transport and dairy cattle, which are kept under favourable conditions and not so exposed as are village cattle to natural infection. Such animals probably possess less immunity.

(ii) Buffaloes vary greatly in susceptibility in different districts; the dose should be from 15 to 45 c.c. per 600 lb. body weight and must be regulated as in the case of plains cattle.

(iii) Cattle of hill breeds require the standard dose of 90 c.c. per 600 lb. body weight.

(iv) Pure bred imported cattle should be given serum at the rate of 150 c.c. per 600 lb. body weight.

(v) For cross-bred (mixed country and imported) cattle the dose will vary from 75 c.c. to 120 c.c. per 600 lb. body weight according to the proportion of admixture with the imported strain.

(vi) Calves under 12 months old should receive larger doses in proportion to their weight than adult cattle.

J. T E.

THE SUPPLY OF PURE SEED IN THE NORTHERN CIRCLE, CENTRAL PROVINCES.

BY

JOHN H. RITCHIE, M.A., B.Sc.,

Deputy Director of Agriculture, Northern Circle, Central Provinces.

One of the first and most important works taken up by the Agricultural Departments in India was an examination of the different varieties which comprised the staple crops of the country, a comparative trial of these varieties and the propagation of the best. After some years of experimenting, the introduction of the best from the point of view of monetary return was pushed by propaganda work. The success of this work has been phenomenal, and whatever criticism the Department of Agriculture has experienced, none has ever been levelled at this branch of the department's activities—a sure indication that the cultivators have appreciated the value of the varieties introduced.

In the Northern Circle of the Central Provinces, wheat is the most important staple, occupying with its mixtures 37 per cent. of the total cultivated area, and the Department of Agriculture has, therefore, devoted much of its time to this crop. The wheats of the province were studied and classified by Mr. Evans, my predecessor, who tested and selected the most promising and introduced them into the various districts of his Circle. So successful has this work been, that in the principal wheat markets of the Circle, the market standard has risen in 15 years from 60-40 (60 per cent. white *pissi* and 40 per cent. other grains) to 90-10. Buyers like Ralli Brothers pay the fixed market rates for 90 per cent. pure grain with a varying tariff for a greater and lesser percentage of impurities.

The introduction of an improved and pure wheat was first made from the Powarkhera farm near Hoshangabad. The variety supplied was A013 (*Sukerhai pissi*) which was a selection from the local mixed wheat. After supplying the needs of the farm, the surplus wheat was given to certain interested *malguzars* for trial alongside the local mixture which up to that time had been their standard wheat. These *malguzars* agreed to grow this wheat under the department's supervision and to rogue out any alien plants found growing in the field devoted to the pure variety. They also agreed to thresh this variety on a separate threshing floor to prevent any mixture creeping in and to store the seed in a separate *banda* and also to reserve all the produce for seed purposes either for themselves or buyers recommended by the department. These growers were called private seed farmers, and every year a considerable number was added to the list. Soon the demand became so

strong and the seed farms so numerous that the department was neither able to supply the pure seed nor to effectively supervise all the crops. In order to overcome this, wheat seed unions were started following the lines of those in Berar for cotton seed. They were constituted as follows :—

A number of seed farmers in a village growing, say, a combined area of 600 acres of seed farm, agreed to have a central seed farm, the produce of which would suffice to sow the whole of the remaining area of the seed farm. The Government farm agreed to supply seed only to this central seed farm every year. The central seed-farm seed would then be sown in the remaining area of the seed farm, the produce of which in the third year would be sold in the neighbourhood for seed purposes or sold in the market for commercial purposes. This system, had it been successful, would have saved large quantities of Government farm seed and would have rendered supervision much easier, but unfortunately dissensions arose amongst the various members of the unions who expected to make the profits which the cotton seed unions of Berar were making, little thinking that the improved wheat fetched nothing like the price that the improved cotton did over the *deshi* varieties and secondly that seed from an acre of cotton will sow from 20 to 30 acres, while an acre of wheat will sow only 6 to 6½ acres.

The demand for seed all over the Circle became so great that Government was forced to open a seed farm in each of the remaining districts of the Circle except Mandla and Narsinghpur. The Government seed farm now serves as the centre for the supply of pure seed to the district by providing the numerous private seed farms scattered all over with a change of seed and by supplying stocks for the opening up of new seed farms which increase every year. At the time of writing there are 925 wheat seed farms with an area of 75,135 acres in the Circle.

In the Betul District, the Government farm supplies seed to a District Seed Association, the members of which take a fixed quantity every year and in turn supply the produce of their farms to the members of the co-operative societies who have the first claim on the seed. The price of seed sold to societies from private seed farms is fixed by a committee of five members of the Seed Association. By this method the advances made by the Co-operative Bank are given in kind and are recouped by the sale of the wheat at harvest time. By so doing large quantities of good seed find a sale in the market and is therefore lost to the department. A scheme for buying in from these societies their surplus stocks of pure seed was devised in 1919 but the Seed Association failed to raise the necessary capital. The Agricultural Department then took the matter up and provided 40 iron bins, capable of storing 100,000 lb. of seed, which could be easily transported and kept sealed in the villages. Pure wheat is now bought at harvest time, stored in these bins through the rains and is sold at sowing time in the vicinity of the stock to help to fulfil the enormous demands for pure seed in the district. These bins are scattered over the district, so that there are a number of small seed depôts within fairly easy reach of most cultivators. The difficulty of transport immediately after the rains is also

overcome. This has been done on a very small scale—only Rs. 5,000 worth of seed being purchased every year. The intention of the department was to show that it was a profitable undertaking, in the hope that some enterprising firm or individuals would take up the work and so provide a pure seed business quite apart from the Agricultural Department. A similar wheat purchase scheme was run last year in the Jubbulpore District with the difference that the seed was supplied to cultivators on *taccavi* loan.

A scheme for supplying seed to co-operative credit societies was started in 1920 in the Sihora Tahsil of the Jubbulpore District where 20 societies were organized to take the seed required by them from the agricultural store there. By the close of 1921 there were 41 societies which held among them 4,197 maunds of seed. The number in 1922 was 64 societies with a capital of 6,620 maunds of wheat and 683 maunds of gram. The method of working is as follows :—

Before sowing, the society proposing to come under the scheme applies to the Co-operative Central Bank for the loan required by it for purchasing seed. The bank examines the finances of the society and, if sound, the loan is sanctioned. Instead of paying the loan in cash, a voucher for the amount is issued to the society which takes it to and gets from the agricultural store seed to the value of the amount mentioned in the voucher. The store has a stock of seed of known vitality, and it makes certain recommendations according to conditions of soil and situation of the village. With this advice, the society takes the quantity of seed and gives an acknowledgment to the store which recovers the cost from the Central Bank. The society is also supplied with a *kuro* measure which is used for issuing seed to and taking back the seed from the members. Free leaflets describing the merits of different seeds and the seed-rate per acre are handed over to the society. The society takes the seed to the village and distributes it among its members. Each member is required to sign an agreement by which he agrees with his society for a period of ten years to take at sowing time the seed from the stock of the society and return it with *sawai barhi* (25 per cent.) at harvest time. The member is also bound to return seed of the same purity as that received by him. After collecting the seed from members at harvest time, the principal is stored in the *banda* (grain pit) of the society and the *sawai* is sold and the sale proceeds are credited into the bank towards the payment of the principal and interest on the loan and towards a sinking and contingent expenditure fund. If a cycle of normal seasons is experienced for 10 years, it is hoped that the society will wipe out all its liabilities for the seed supplied and will be in possession of a good and pure stock of seed. The members are in touch with the Agricultural Department from which they receive training in improved methods of agriculture and thus benefit greatly.

Another recent development of the seed supply business in the Sihora Tahsil was the supply by Government to the Tahsil Agricultural Association at sowing time of 100 *khandis* (20,000 lb.) of pure seed returnable on a 10 per cent. *barhi* in kind at harvest time. The association issued this seed to its members on a *barhi* of 20 per cent., thus

making a profit of 10 per cent. This *barhi* system is based on the local custom by which cultivators obtain seed from their *malguzars* or from *banias* at sowing time and return $1\frac{1}{4}$ times the amount (*sawai*) at harvest time. The intention of the department was to encourage the agricultural association to adopt this system which is a very profitable one, and with the hope that if the scheme developed sufficiently the local rate of *barhi* would be brought down from 25 per cent. to a lower figure and thereby give relief to the cultivating classes. A similar quantity of seed has been given to the Katni Tahsil Agricultural Association this year on the same terms as that supplied two years ago to the Sihora Association.

A few Tahsil and Sub-associations have collected their own stocks of seed and are issuing it on the *barhi* system. This is quite a recent undertaking and every encouragement and help are being given by the Agricultural Department to enable agricultural associations to start this work which will be greatly appreciated by the cultivators.

Small village seed unions have been very popular of recent years in certain districts of the Circle. These were devised in 1922 to stimulate self-help and simple co-operation in the village community. The members contribute at harvest time a quantity of grain to a common fund which is credited to their accounts. The total quantity thus collected is sold and with the proceeds pure grain is bought, or, more usually, this quantity is exchanged with pure seed by the Agricultural Department. With this stock, which in many cases amounts to several thousands of pounds, the union does grain-lending business on the *sawai* system to its members. Gradually the stock will increase and each member will get returned the quantity he contributed but of pure instead of mixed seed. When a sufficient quantity has been acquired, some will be sold to purchase ploughs or threshers or winnowing machines for the use of the members. In villages where there is no *bania* dealing in seed and in others where the *malguzars* are sympathetic towards their tenants, these unions are very easily organized and have been very successful. At the time of writing there were 52 such village unions in the Circle with a membership of 695 and holding stocks of wheat and paddy amounting to 630 maunds.

The dissemination of paddy and other seeds does not require the same elaborate organization as wheat because the areas are relatively small. In the case of paddy, which is grown on a largish scale only in the Jubbulpore, Mandla and Damoh Districts of the Northern Circle, private seed farms have been found to cope sufficiently with the demand for seed. The village seed union idea has caught on for paddy too, and many of the societies mentioned above deal with both wheat and paddy. The only other grain for which special arrangements have been made in the past is Purvi Maghi *til* (sesamum), but the quantity required per acre is such a small fraction of the yield that no great difficulty has been experienced in distributing the seed. This variety has so completely ousted the ordinary *kharif til* that the department no longer troubles about it beyond the fact of renewing the seed of certain seed farms every year to maintain purity.

The ideal which it is hoped to work up to is as follows :—The Government seed farm will supply seed every year to certain central seed farms so situated as to command as far as possible an equal area. These will give out as seed all their produce to ordinary seed farmers in the villages commanded by the central seed farm. The wheat from these seed farms will be kept to meet the demand from the remaining cultivators of the villages. The seed farm owners will be members of the agricultural sub-association and they will raise share capital to enable them to buy in from cultivators their surplus pure seed. This will be sold to reputable merchants or firms who give a good price for pure and better quality seed. As there will be large quantities to be disposed of and as the samples will be uniform the price will be better than if only small consignments were offered. The sub-association will pay to the cultivators at the time of purchase something below the standard market rate ruling for ordinary wheat and will square up his account after the sale of the grain. The elimination of the middleman is thus secured and the cultivators will benefit enormously. A small charge for doing this work will be made by the association to pay expenses and in order to pay a dividend to the shareholders who, however, should profit sufficiently by the co-operative sale of their produce and by the disappearance of the middleman's share.

This co-operative sale will have to be undertaken on a small scale at first, but the quantities will be sufficiently large to obtain the best prices and to give the association a name for excellence of sample.

THE FODDER PROBLEM IN ITS RELATION TO CATTLE-BREEDING.

BY

D. CLOUSTON, C.I.E., M.A., D.Sc.,

Agricultural Adviser to the Government of India.

At the tenth session of the Indian Science Congress held at Lucknow in 1923, a joint meeting to discuss ways and means of improving the supply of fodder and forage in India was arranged by the Presidents of the Sections of Agriculture and Botany. The papers read at this joint meeting were afterwards published as one of the bulletins of the Agricultural Research Institute, Pusa. This bulletin, No. 150 of the Pusa series, is well worth perusal, giving as it does a general survey of the wider aspects of the fodder question in different parts of India.

Efforts are being made on Government farms in several provinces in India to improve the local breeds of cattle by selective breeding and cross-breeding. It is everywhere felt, however, that any improvement of our breeds must be preceded by an improvement of the fodder supply; for in the realm of animal husbandry better feeding is just as important a factor as better breeding. The fodder question in this country is largely one of economics. The bulk of the cultivators are small men, each cultivating an area of only a few acres, no part of which is ordinarily set aside for the cultivation of fodder crops only. His cattle are grazed on the waste lands and grazing grounds common to the whole village where the pasture available is poor in quality and very limited in quantity. In addition to the food they pick up on these pasture lands so called, draught bullocks and cows kept for milk are ordinarily given crop residues consisting mainly of wheat and rice straw, *juar* (sorghum) stalks, the husks of certain grains with a little oil-cake and cotton seed where and when that is available. But the amount of these crop residues is very small as compared with the number of mouths to be fed, with the result that his cattle have to subsist from December till July, *i.e.*, throughout the dry season, on a ration which falls far short of the maintenance standard. During this period they undergo a period of semi-starvation and lose condition in consequence. In the neighbourhood of forests open for grazing the position is somewhat better, but not much; there, too, the pasture is burnt up when most required. For cows in calf this treatment is particularly detrimental; with the mother in a run-down condition the calf suffers for want of nourishment both before and after birth.

The remedies commonly suggested for this state of affairs are to throw open larger forest areas, including reserved forests for grazing, and to increase the area

set apart for this purpose in villages too. With regard to the first of these remedies, I need only say that it would not go far to solve the fodder problem, even if Government were prepared to sacrifice its forests, in the interest of cattle-owners; for owing to climatic conditions the grasses in the forests, like those in village grazing areas, get burnt up in the dry season and lose much of their nutritive value. The great bulk of the villages in India are, moreover, so far distant from forest lands, that the villagers cannot conveniently send their cattle there for grazing. The advocates of the second remedy aver that within the last half century cattle have deteriorated owing to the reduction of village grazing areas. They forget, however, that within that period peace and comparative plenty have fostered an enormous increase in the human population, both in towns and villages, and that this ever increasing population must be fed. But even if it were feasible to increase grazing areas at the expense of cultivated land, that would not go far to solve the fodder problem; for during the dry season of the year village grazing lands do not provide pasturage worthy of the name. In the past when large grazing areas were available, the cultivator relied almost entirely on Nature to provide food in the form of pasture for his cattle. To this improvidence we mainly attribute the inferiority of the ryots' cattle in this country. The increase in population and reduction in the area of pasture lands have given rise to rural problems which are new to him, and he is only beginning to readjust his system of farming to meet the new conditions which face him. In some parts of India it cannot be said that even a beginning has yet been made; but in the more advanced provinces where grazing areas have been reduced to a minimum, fodder crops are being grown and cattle are being stall-fed. In these provinces the cultivators realize that any increase in the grazing area at the expense of that suitable for cultivation would merely encourage cattle owners to keep larger numbers of useless cattle, and that this would increase still further the pressure on food supplies. It is a fact that in the more backward parts of India where grazing areas are large, no provision is yet made for growing or storing fodders; and thousands of cattle are kept for no other purpose than to produce dung, the annual value of which is reckoned to be about Re. 1 or at most Rs. 2 for each animal. The existence of large grazing areas is, in short, one of the factors which retard progress in animal husbandry in India to-day. It is in the direction of tillage that scientific and economic advances are possible; for tillage unites the two great branches of farming, namely, bread production and live-stock rearing.

Cattle rearing over the greater part of rural India is thus handicapped, to a great extent, by the fact that there is not enough fodder produced in the average village to meet the annual requirements of the animals kept therein. Further, cattle-owners do not carry over the surplus available at the end of the rains—for use from December till July when grazing areas are parched and bare. There is besides no carry-over from one year to another, with the result that in years of short rainfall the fodder problem becomes acute. The Agricultural Department has of late years given much attention for that reason, to the question both of growing and storing

fodders. Several very promising fodders have been introduced and methods of storing them in the dry state and as ensilage have been adopted on Government farms throughout the country. It has been definitely proved, moreover, that good palatable ensilage can be made from coarse grasses, weeds and other herbage which in most parts of India are available in considerable quantities towards the end of the rains. Crops such as maize and *juar* cut and siloed when in flower also make excellent ensilage as experience has shown.

There are definite types of silos in use on Government farms and on the military dairy farms in India ; but they may be divided roughly into two classes, *viz.*, (1) *pucca*, and (2) *kutcha* silos. The former are, perhaps, too expensive except for the well-to-do landowner. The *kutcha* silo, on the other hand, which consists merely of a pit in which the fodder is stored in the green state and covered with a thick layer of earth, costs very little, and is well within the means of the ordinary ryot. Such silos are in use on many Government farms in this country. At the Imperial Cattle-breeding Farm at Karnal pits dug in the heavy alluvium soil and filled four years ago with green *juar* were opened last cold weather : the ensilage at the end of four years was found perfectly sweet and good. This method of storing fodder in the green state, when it is abundant and not required for immediate use, should in course of time commend itself to the more enterprising agriculturists of this country. It is a method which, if adopted by stock-owners, would enable them to provide their cattle with a luscious food in the dry weather when grazing areas are parched and bare.

What, it may be asked, can the Imperial and the Provincial Departments of Agriculture do to popularize the use of ensilage as a cattle food ? They can and are doing much by example and precept ; ensilage is now being made on Government farms and cultivators are encouraged to visit these farms and to study the process of ensilage making. In some provinces lectures illustrated by magic lantern slides are being given. A very excellent cinema film illustrating in detail the processes involved in making ensilage in *kutcha* pits has been prepared at Pusa and will, we hope, be available for use in the provinces. By carrying on propaganda on these lines it should, in the course of the next 20 years, be possible to effect considerable improvement both in the production and storage of fodders in this country ; but the apathy of India's landowners towards agricultural development generally will first have to be broken down. Until this is accomplished, animal husbandry will continue to suffer neglect, and the high standard of cattle-breeding and cattle-feeding aimed at on Government farms will be of little avail. But to bemoan our difficulties will not remove them : we must look for a remedy. This apathy can be dispelled only by giving the sons of the landowners a more scientific and practical education. The type of literary education given them in the past has alienated their sympathies from agricultural pursuits. Realizing this, Government has within the last two decades evolved a system of agricultural education based on science and practice. The indications are that this type of education, as provided for at

our provincial agricultural colleges and the Imperial Institute of Animal Husbandry and Dairying at Bangalore, will go far to foster a real practical interest in animal husbandry and dairying in this country. The men trained at these institutions will, we trust, in course of time aspire to do for animal husbandry in India what the gentlemen farmers of England have done for it in that country which is now regarded as " the stud farm of the world ".

FEEDING STANDARDS AND THEIR APPLICATION TO DAIRY CATTLE IN INDIA.

BY

F. J. WARTH, M.Sc.,

Physiological Chemist, Imperial Department of Agriculture.

Feeding standards.

The food consumed by an animal is used to supply energy to replace waste and to provide material for growth or milk production. Each of these heads will be considered separately.

Food as a source of energy. All organic foodstuffs are combustible and liberate energy when they undergo oxidation. The oxidation taking place in the animal body is measured by the amount of CO_2 exhaled. A resting bullock on a maintenance ration may breathe out as much as 7 lb. of CO_2 in 24 hours.

Consumption of food and the performance of work, both processes involving expenditure of energy and a higher state of cellular activity, result in very greatly increased respiration, oxidation and CO_2 production. The energy liberated by this oxidation process is utilized for carrying out the vital functions, for supplying the extra energy demanded by heightened cellular activity and for the work of digestion. The energy thus utilized is finally emitted as body heat—the amount of which is exactly equal to the amount of energy liberated by oxidation.

It has to be observed that all the energy of ingested food is not available for the vital functions. The undigested fraction is not utilized at all. Of the digested fraction, part is lost through incomplete oxidation (urinary excretion and fermentation). Finally, a considerable deduction has to be made from the assimilated energy for the work of digestion and for the heightened cellular activity which the ingestion of food causes. The residual or net energy after making these deductions is the amount which is available for carrying on the vital functions and for productive purposes.

The following table shows the magnitudes of the deductions which have to be made and the resulting net energy values of a variety of foodstuffs. The figures have been calculated from Armsby's data and the unit of energy—the therm=1,000 calories—is the unit used by him.

TABLE I.

Net energy values of common foodstuffs (Armsby). Therms per 100 lb. foodstuff.

	Gross energy	Undigested fæces	Percentage digested	Digested energy	Further deductions	Net energy	Digestible protein
100 lb. of—							
Meadow hay	201	81·4	59·0	118·6	76·9	41·7	4·5
Clover hay	202	84·6	58·1	117·4	70·8	46·6	8·1
Alfalfa hay	199	87·8	55·9	111·2	77·1	34·1	10·6
Oat straw	201	114·2	43·2	86·8	60·8	26·0	1·0
Rice straw	153	78·0	49·1	75·0	52·0	23·0	0·9
Wheat straw	201	116·7	41·8	84·3	73·2	11·1	0·7
Wheat bran	205	64·5	68·2	140·5	80·0	60·5	12·5
Groundnut cake . . .	211	32·0	84·9	179·0	97·4	81·6	41·0
Cotton-seed cake . . .	207	44·1	78·7	162·9	78·1	84·8	32·0

It will be noted that with the exception of fats the total energy of all foodstuffs as measured by the heat of combustion or gross energy is very similar, whilst the net energy values may range from 11 to 100 therms. The primary factor limiting the net energy value of a food is its digestibility. It will be noticed that high net energy values are given only by the highly digestible concentrates. The figures lay stress upon the importance of digestibility determinations.

The term starch equivalent requires mention and definition here. Kellner in his classical work on nutrition compared the net energy values of all foodstuffs with starch and expressed the results as starch equivalents. The starch equivalents used so largely in Europe are simply another unit for expressing net energy values, 1 starch equivalent being 1·07 therms, which is the net energy value of starch. To avoid needless duplication of data only therms of net energy will be quoted in this paper. From the relationship given above the figures can easily be converted into starch equivalents if desired.

Food to replace waste. The processes of life involve indispensible oxidations and chemical changes in the constituents of the living cells and the products of disintegration so formed are excreted in the breath, urine and sweat. The digested food has to make good these losses.

We come now to an important distinction between the different ingredients of foods. Whilst the requisite energy may be derived from the oxidation of any organic substance, the losses sustained by the body can only be replaced by particular com-

pounds. The loss of flesh or body protein requires food protein, and all food proteins are not equally efficient for this purpose. The loss of mineral matter can only be made good by a supply of the particular minerals which have been excreted. Fat, however, can be built up from any organic food. Usually the carbohydrates of the food provide the source of body fat.

Food for growth. In this case again the food required will depend upon the constituents which compose the gain made. The following table shows the nature of the gains made by dairy breeds of cattle in America.

TABLE II.

Composition and energy values of live weight increases.

Weight of animal	Composition of 1 lb. gain				Energy of gain (therms)
	H_2O	Protein	Fat	Minerals	
lb. 100	0·66	0·20	0·08	0·05	0·86
200	0·63	0·20	0·13	0·04	1·22
300	0·60	0·19	0·17	0·04	1·42
400	0·57	0·18	0·22	0·03	1·60
500	0·54	0·17	0·27	0·03	1·82

The main point brought out by these figures is that the nature of the gain varies with the size and age of the animal. In the young calf the gain consists of watery flesh with a relatively high proportion of mineral matter and very little fat. The total energy content is low, and to produce 1 lb. of such a gain somewhat less than 1 therm of net energy of food will suffice. An animal which is approaching maturity gains very different material. The water content of the gain is much less, the protein and minerals are slightly less, the fat is very much more. On account of the higher proportion of fat and lower proportion of water the energy content of the gain is very much greater. Such an animal may require 3 or 4 times as much net energy as a young calf to produce 1 lb. of gain. It should be mentioned here again that animal fat is mainly derived from the carbohydrates and not from the fats in the food. The ration should provide twice the amount of protein contained in the gain because food proteins are not capable of producing flesh protein weight for weight.

The maintenance ration. A maintenance ration is one that supplies the needs of a resting animal without leaving a margin for work, growth, or fattening. Such a ration provides the protein and minerals required to replace losses, and net energy sufficient to carry on the vital processes.

The accompanying table gives the average maintenance requirements of cattle of different sizes. There is some uncertainty regarding the figures given for young stock.

TABLE III.

Maintenance requirements.

Live weight	Digestible crude protein	Net energy (therms)
lb.		
100	0·16	1·29
200	0·26	2·05
400	0·40	3·26
600	0·51	4·27
800	0·61	5·17

It will be noticed in this table that no mention is made of the mineral requirements. Experience has shown that rations which provide a sufficiency of protein generally contain all the necessary minerals. This is not absolutely correct. Salt must be provided always, and in certain exceptional cases also lime and phosphoric acid.

The requirements for growth. A growing animal requires food for two purposes, namely, maintenance and growth. The combined requirements are given in the accompanying table.

TABLE IV.

Requirements for growing animals.

Weight (lb.)	Digestible crude protein (lb.)	Net energy (therms)*
100	0 32	3·10
200	0 67	3·60
300	0·80	4·25
400	0 87	5·10
500	1·04	6·20
600	1·22	6 90

* According to Armsby's standards.

An example will make the use of this table clear. We wish to determine a ration for a 200 lb. growing heifer. The requirements are 0 67 lb. digestible protein and 3·6 therms net energy. This could be conveniently provided by the following foodstuffs: grain mixture yielding 24 lb. digestible protein and 86 therms net energy per lb., and hay yielding 3 lb. digestible protein and 48 therms net energy. Thus,

	Digestible protein (lb.)	Net energy (therms)
2½ lb. mixture	0·60	2·15
3 lb. hay	0·09	1·44
TOTAL	0·69	3·59
Total dry matter	4·9 lb.	

The requirements for milk production. The requirements depend upon the composition of the milk. The higher the fat content, the greater is the energy content of the milk. The work of Eckles has shown that the net energy required for the production of rich milk is not only absolutely but also relatively greater than that required for poor milk. The figures in the accompanying table have been calculated from Eckles' data.

TABLE V.

The net energy requirements for milk production.

Milk		Food requirements per lb. milk	
Fat percentage	Energy per lb.	Digestible protein (lb.)	Net energy (therms)
3·0	0·26	0·050	0 22
4·0	0·31	0·055	0·30
5·0	0·36	0·062	0·39
6·0	0·42	0·070	0·48

These figures are obtained on the assumption that the net energy values of foods determined with bullocks on maintenance rations apply to cows in milk. The assumption enables us to use the ordinary net energy value tables for milk production.

With data contained in Tables III and V the requirements of a cow weighing 800 lb. and yielding 40 lb. of 4 per cent. milk are calculated thus :—

	Digestible protein (lb.)	Net energy (therms)
Required for—		
Maintenance	0·60	5 17
40 lb. 4 per cent. milk	2 20	12 00
TOTAL . . .	2·80	17·17

A ration would have to be selected, as in the case above, to provide these quantities.

THE APPLICATION OF THE STANDARDS TO THE RATIONING OF DAIRY CATTLE IN INDIA.

In applying these principles, two qualifying statements are necessary. (1) A ration is not completely defined by the figures for digestible protein and net energy.

There are other conditions which the ration must fulfil. Amongst these the nutritive ratio, the bulk of the ration (as defined by total dry matter), the minerals and accessory factors (vitamines, etc.) which it provides, have to be taken into account. (2) There is very considerable doubt regarding the net energy values to be assigned to certain Indian foodstuffs. That is to say, there are gaps in one of the tables which we have to use for calculating rations.

Some of these points will be discussed briefly.

The nutritive ratio, *i.e.*, the ratio of carbohydrate to protein, affects the palatability and digestibility of a ration. The nutritive ratio for young animals must be narrow for both these reasons. Mature animals with a better capacity for digesting carbohydrates are fed on wider ratios.

In Europe and America, the protein fraction of the ration is generally the most expensive part. Extensive experiments have been made to determine the lowest proportion of protein which will yield good feeding results. In this connection the monumental and classical enquiry on milk production carried out for a period of 11 years by Haecker in America may be cited. It is true he determined the amounts of nutrients required for rich and poor milk respectively, but the main effort of this great work was directed to show that milk could be produced with a lower protein ration and more starchy food. This was a very valuable result for a region in which proteins are more costly than starchy grains. But in India the reverse is generally true. In many large areas proteins cost less than starches. Therefore, the results of this enquiry, which is one of the most extensive feeding tests ever undertaken, do not help us in India. Our problem in fact is to make the best use of the relative abundance of protein. We can certainly afford to feed rations with narrower nutritive ratios than those specified in text-books. This remark applies especially to cows in milk and to growing animals over a year old. The feeding of younger stock should not depart from accepted standards until conclusive evidence is produced to show the efficiency of other rations. A very narrow ratio is likely to be unwholesome, and such narrow ratios may often be unwittingly fed (especially to young stock) when a rich cake is used to make up for the shortcomings of an indigestible coarse roughage. This danger is likely to be met with in India.

Bulk of ration. For the satisfactory development of the young animal's digestive system, and to give the fully grown animal a feeling of satisfaction, the ration should be so selected that it provides the necessary nourishment in suitable bulk. Sometimes a ration may not be bulky enough. More often in India it is likely to be too bulky. The following example is instructive in this connection.

A heifer weighing 300 lb. and gaining a pound a day requires, according to the table of standards, 0·80 lb. digestible protein and 4·25 therms net energy. Given a good concentrate mixture supplying 90 lb. dry matter, 37 lb. digestible protein and 87 therms net energy, and a poor straw supplying 90 lb. dry

matter, 0·4 lb. digestible protein and 21 therms net energy, a ration has to be calculated—

	Digestible protein lb.	Net energy therm	Dry matter lb.
2 lb. mixture	0·74	1·74	1·8
12 lb. straw	0·05	2·52	9·6
TOTAL	0·79	4·26	11·4

With respect to nutrients and net energy the ration is satisfactory but its bulk is altogether out of proportion to the animal's capacity. The heifer in question could probably consume 7·5 lb. of dry matter a day comfortably. The ration proposed is 50 per cent. above the animal's stomach capacity. The bulk can be reduced by increasing the concentrate and reducing the straw, but with these materials a really satisfactory ration cannot be obtained. Cases of this kind are likely to occur in India. The substitution of fresh fodder or silage for part of the straw would make an excellent combination.

Mineral requirements. The most important mineral ingredients supplied by the food are lime and phosphoric acid, both of which are required as essential constituents of the flesh and of milk as well as of the skeleton. Recent work has shown that the assimilation of these minerals is not necessarily in proportion to the amounts supplied in the ration. The assimilation of lime (and with it phosphoric acid) is facilitated by the presence of some other factor in the food. The nature of the substance which possesses this remarkable power is not known. The factor is present in green fodders, especially in legumes and in cod-liver oil. That is to say, by adding green legume or cod-liver oil to a ration and without increasing its lime content more lime is assimilated by the animal. The assimilation of lime is also generally but not always increased by adding lime to the ration. To ensure that the animal assimilates all the lime it needs the supply of lime in the ration must be assured and the factor favouring assimilation must be provided. Fresh cut lucerne provides the factor, whilst additional lime to that contained in the foodstuffs is likely to be necessary under the following conditions:—

(*a*) Sometimes when the roughage provided has been grown on acid soils.

(*b*) More frequently when the roughage consists of crop residues of the cereals or of over-ripe hay.

Both these conditions are of common occurrence in India.

Net energy value of Indian foodstuffs. In order to employ the modern feeding standard in India we must first know the net energy values of our foodstuffs. It will be most useful at this stage to state definitely what is known and what is not known with regard to this matter. In the first place, many of the concentrates used in India, Europe and America are identical in composition and quality. For these reliable net energy values are available. Some concentrates cannot be disposed of so easily. For example, the wheat bran used in this country is hardly

ever up to European standard. Secondly, there is reason to believe that fresh green fodders grown in India have about the same net energy values as corresponding materials for which data have been obtained in Europe and America. This leaves a large and very important class of dry roughages, crop residues, and Indian hay to be considered. These products have matured under conditions which are peculiar to India. In composition they differ to an appreciable extent from corresponding products obtained abroad. It is reasonable to conclude that the net energy values of these Indian products will differ considerably from their closest representatives which have been tested elsewhere. From experiments at present in progress at Bangalore these conclusions are amply borne out in regard to samples of Indian hay, the estimated net energy of which is distinctly lower than that of average American hay. For the present and until exact data are available, low net energy values must be assigned to foodstuffs belonging to this class.

THE ORIGIN OF ALKALI LAND.

BY

ALBERT HOWARD, C.I.E., M.A.,

Director, Institute of Plant Industry, Indore, and Agricultural Adviser to States in Central India.

In a recent review[1] of the agricultural investigations in India of the last twenty years, the idea was advanced that the origin of alkali land is closely bound up with defective soil-aeration. It was suggested that anærobic bacteria, by bringing about a reductive phase in the soil, are probably the real agents which give rise to the harmful salts which occur in alkali tracts. Several examples of the intense reduction which precedes the formation of these salts were quoted. In the alkali zone of North Bihar, wells have to be left open to the air otherwise the water is contaminated with sulphuretted hydrogen, thereby indicating a well-marked reductive phase in the deeper soil layers. In a sub-soil drainage experiment in the alkali lands of the Nira valley in Bombay, Mann and Tamhane[2] found that the salt water which ran out of these drains soon smelt strongly of sulphuretted hydrogen and a white deposit of sulphur was formed at the mouth of each drain, proving how strong were the reducing actions in this soil. Here the reductive phase in alkali formation was actually demonstrated.

After *Crop-production in India* was printed in 1924, the observations of Dr. Ferdinand Ossendowski, now Professor in the Military Academy of Warsaw and formerly in the service of the Imperial Russian Government, on the origin of salt water lakes have become available. Dr. Ossendowski was fortunate enough to observe vast colonies of reducing bacteria in lake Szira-Kul in Siberia and to record the intermediate stages between an ordinary fresh water lake and the reservoirs of dead salt water which occur in many parts of Asia. It is not unlikely that the transformation of a fresh water into a salt lake has much in common with the gradual alteration of fertile soil into dead alkali land and that these two things should be studied together as parts of a single problem.

In view of the urgent necessity for further work on the origin of alkali salts in the soils of Sind and North-West India, the following extracts from Dr. Ossendowski's latest work[3] appear to be worthy of attention :—

"The big lake Szira-Kul, which signifies "bitter lake," is situated between Bateni and the mountain range of Kizill-Kaya, quite near the latter's slopes. The

[1] *Crop production in India*, Oxford University Press, 1924, p. 43.
[2] *Bull 39, Dept. of Agri., Bombay*, 1910.
[3] *Man and Mystery in Asia*, London, 1924, p. 5.

lake is an oval, about 7 miles long and 3 miles wide, and lies in an unforested valley. At its north end reeds grow round the mouth of the small stream of fresh water which flows into it at this point. The lake is a reservoir of mineral, bitter, saltish water good for healing baths and efficacious in stomach diseases. A village with a small medical and bathing installation is situated on the eastern shore.

* * * *

"Taking from the bottom of the lake samples of ooze, black and cold, with a temperature never exceeding 34·6 degrees and always smelling of hydrogen sulphide, we remarked a strange phenomenon. After an exposure of some time in the open air, long, movable grasses of pale-yellow colour grew from this ooze, only to disappear soon without leaving any traces. It looked as though some being living in the ooze extended its feelers and then withdrew them. And really this was exactly what happened, as these were colonies of *Beggiatoæ* bacilli, those precursors of the death of sea and lakes, which appear when some of the salts are decomposing and forming the hydrogen sulphide which kills all life in these reservoirs.

"Continuing our studies, we found at a certain distance below the surface an immense network formed of a great number of these colonies twined together, which rose up from the bottom gradually higher and higher, killing all symptoms of life. The lake was therefore quite dead, except that portion above the network wherein there still lived some diminutive crawfish, called *hammarus*, similar to ordinary shrimps but very small, being no more than 1 centimetre in length but as quick and bold as their sea relatives. However, the time will come when the quantity of hydrogen sulphide created by the *Beggiatoæ* will also kill these last representatives of the former fauna of the lake and the process of dying in the lake will be ended as the bacilli themselves will in turn be poisoned by their own pernicious gas.

"Later on I studied with Professor Werigo the limanes near Odessa and some regions of the Black Sea. The identical process of dying was taking place here and after a longer or shorter period it will also even completely destroy the life of the Black Sea. The fish, sensing this process, are gradually leaving this sea, because they find in its depths these poisoned layers of water which are gradually rising towards the surface.

"This is the sad and gruesome process of the death of great water basins, which are metamorphosed into lifeless reservoirs of salt water smelling of hydrogen sulphide. The Dead Sea in Palestine has long since been such a reservoir, and great numbers of similar ones are scattered over the immense plains of Asia."

THE NITROGEN AND MINERAL REQUIREMENTS OF THE PLANTAIN.

BY

ROLAND V. NORRIS, D.Sc.,

Formerly Government Agricultural Chemist, Coimbatore;

AND

C. V. RAMASWAMY AYYAR, L.Ag.,

Assistant to the Government Agricultural Chemist, Coimbatore.

In order to obtain some idea as to the amount of plant food taken up by the plantain tree, it was considered desirable to undertake an analysis of the different parts of a complete mature tree. In this way the total food requirements could be estimated, while interesting information in regard to the distribution of the various constituents would also be obtained.

The tree examined was taken from the Samalkota Experimental Farm, a full grown tree bearing fruit being used for the experiment. Care was taken that all the roots, suckers, etc., were removed with the tree. The various parts—roots, stem, leaves, etc.—were then immediately weighed and the total weight of the tree thus obtained.

The material was then despatched to the laboratory where the remaining determinations were carried out. The analysis was in no sense complete but confined roughly to substances of manurial interest, and hence the only determinations made were moisture, nitrogen, total ash, potash, phosphoric acid, lime, magnesia and insoluble mineral matter (silica). The results obtained are summarized in the tables which follow.

TABLE I.

Weight and moisture content of different portions of the tree.

Part of tree	Weight of original material in fresh state	Weight of moisture free material	Percentage of moisture
	Grm.	Grm.	
Fruit—			
Stalk	13,154	70 55	79·77
Pulp		1,804 00	
Rind		786 60	
Leaves	10,660	1,935 00	81·85
Leaf sheaths	27,330	2,551·00	90·67
Central stalk	7,145	537·40	92·48
Suckers	2,269	118 10	94·80
Rhizomes of suckers	13,610	1,649 00	87 89
Roots	4,536	326 80	92·82
Rhizomes of main tree	9,072	1,202·00	86·76
TOTAL	87,776	10,079·45	87·50

* Paper read at the Agricultural Section of the Indian Science Congress, Benares, 1925.

TABLE II.

Percentage of nitrogen and total ash in different parts of the tree.

Part of tree	Nitrogen			Total ash		
	Weight of nitrogen	Per cent. in fresh material	Per cent. in dry material	Weight of ash	Per cent. in fresh material	Per cent. in dry material
	Grm.			Grm.		
Fruit—						
Stalk	0·736		1·07	16·18		22·94
Pulp	11·530	0·15	0·64	81·19	1·27	4·50
Rind	7·883		1·00	71·08		9·04
Leaves	28·940	0·27	1·49	397·00	3·72	20·51
Leaf sheaths	15·120	0·05	0·59	347·90	1·27	13·64
Central stalk	4·403	0·06	0·82	91·07	1·27	16·94
Suckers	2·242	0·09	1·90	22·94	1·01	19·43
Rhizomes of suckers	25·630	0·18	1·55	160·30	1·17	9·73
Roots (main tree)	2·815	0·06	0·86	64·83	1·42	19·90
Rhizomes of main tree	12·150	0·13	1·01	125·60	1·38	10·44
TOTAL	111·469	0·12	1·01	1,378·09	1·57	12·55

TABLE III.

Distribution of K_2O, P_2O_5, CaO, MgO, and insoluble mineral matter.

Part of tree	Potash: Weight of K_2O	Potash: Per cent. in fresh material	Potash: Per cent. in dry material	Phosphoric acid: Weight of P_2O_5	Phosphoric acid: Per cent. in fresh material	Phosphoric acid: Per cent. in dry material	Lime: Weight of CaO	Lime: Per cent. in fresh material	Lime: Per cent. in dry material	Magnesia: Weight of MgO	Magnesia: Per cent. in fresh material	Magnesia: Per cent. in dry material	Insoluble matter: Weight	Insoluble matter: Per cent. in fresh material	Insoluble matter: Per cent. in dry material
	Grm.			Grm.			Grm.			Grm.			Grm.		
Fruit—															
Stalk . .	8·316		11·79	0·837		1·19	0·650		0·92	0·618		0·88	1·140		1·61
Pulp . .	29·940	0·55	1·66	5·666	0·08	0·31	2·060	0·04	0·11	5·595	0·06	0·31	1·545	0·05	0·08
Rind . .	34·35		4·37	4·364		0·55	2·417		0·31	2·917		0·37	3·491		0·44
Leaves . .	73·35	0·68	3·79	6·939	0·06	0·36	63·080	0·59	3·26	12·180	0·11	9·68	154·700	1·45	7·99
Leaf sheaths .	102·40	0·37	4·02	10·800	0·04	0·42	46·610	0·17	1·83	37·050	0·13	1·45	32·490	0·13	1·27
Central stalk .	37·11	0·51	6·90	2·490	0·03	0·16	2·873	0·04	0·53	5·546	0·07	1·03	12·390	0·17	2·30
Suckers . .	10·86	0·47	9·14	1·240	0·05	1·05	1·030	0·04	0·87	0·898	0·04	0·76	1·340	0·06	1·13
Rhizomes of suckers.	68·74	0·50	4·17	9·915	0·07	0·60	7·082	0·05	0·43	1·026	0·007	0·06	12·290	0·09	0·74
Roots . .	15·52	0·34	4·76	0·989	0·02	0·31	8·480	0·18	2·60	2·848	0·06	0·87	13·510	0·29	4·14
Rhizomes of main tree.	56·44	0·62	4·69	3·674	0·04	0·30	6·680	0·07	0·56	8·908	0·09	0·74	5·774	0·09	0·73
TOTALS .	436·966	0·49	3·90	46·914	0·053	0·45	140·962	0·16	1·28	77·586	0·088	0·70	241·670	0·27	2·20

TABLE IV.

Percentage composition of ash.

Part of tree	K_2O	P_2O_5	MgO	CaO	Insoluble mineral matter
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Fruit—					
Stalk	51·3	5·1	3·8	4·0	7·0
Pulp	36·8	6·9	6·8	2·5	1·9
Rind	48·3	6·1	4·1	3·4	4·9
Leaves	18·4	1·7	3·0	15·8	38·9
Leaf sheaths	29·4	3·1	10·6	13·3	9·3
Central stalk	40·7	2·7	6·0	3·1	13·6
Suckers	47·0	5·4	3·9	4·4	5·8
Rhizomes of suckers	42·8	6·1	0·6	4·4	7·6
Roots, main tree	23·9	1·5	4·3	13·0	20·8
Rhizomes, main tree	44·9	2·9	7·0	5·3	6·9
Percentage of total ash	31·7	3·4	5·6	10·2	17·7

The complete tree weighed 87·776 kilos and contained on the average 87·5 per cent. of moisture or 12·5 per cent. dry matter, the moisture content varying from 79·8 per cent. in the fruit to 94·5 per cent. in the suckers.

Nitrogen. Nitrogen is distributed fairly evenly throughout the tree forming about 1 per cent. of the dry material, the highest proportions being found in the suckers, the rhizomes of the suckers and in the leaves.

Ash. The amount of ash varies from 4·5 per cent. of the dry matter in the fruit pulp to 22 per cent. in the stalk of the fruit and in the whole tree forms 12·5 per cent. of the moisture-free matter.

Potash. The most striking feature of the analysis is the amount of potash (K_2O) in nearly every part of the tree. In fact potash accounts for nearly 4 per cent. of the dry weight and for 31·7 per cent. of the total ash. It is, therefore, much the most important of the constituents examined. The highest percentage (11·79) is found in the stalk of the fruit which also contains the highest percentage of total ash. Potash is generally considered necessary for carbohydrate formation and it is therefore somewhat surprising to find that the leaves contain a smaller amount of this substance than any other part of the plant. In the case of the coconut palm, where a somewhat similar examination has been made, the young leaves all contained a high percentage of K_2O which diminished as the leaves aged and functioned less vigorously. In the present case the tree had reached the fruiting stage, and it is possible if the examination had been carried out at an earlier period the distribution of potash might have been somewhat different. The suckers contain the second highest percentage of K_2O (9·14 per cent.), and this concentration is doubtless connected with the requirement of the next generation.

Phosphoric acid. Phosphoric acid (P_2O_5) is present in smaller amounts than any of the other constituents, forming only 0·45 per cent. of the total dry matter and 3·4 per cent. of the total ash. It occurs chiefly in the fruit stalk and suckers, while the leaves and the roots contain but little (0·31 per cent.)

Lime. Lime appears to be of considerable importance and forms 1·28 per cent. of the dry matter and 10·2 per cent. of the ash. It occurs chiefly in the leaves and leaf sheaths where it forms about 15 per cent. of the ash and doubtless helps, in conjunction with silica, to give the necessary strength to these parts. The roots also contain a high percentage but the amount found in other parts of the tree is but small.

Magnesia. Magnesia is present in moderate amounts forming 0·7 per cent. of the dry matter and 5·6 per cent. of the ash. The distribution is somewhat irregular as in the case of the coconut palm, the highest percentage being found in the leaf sheaths.

Insoluble mineral matter. The leaves, the roots and the central stalk contain large amounts of silica, especially the leaves where this substance constitutes nearly 40 per cent. of the ash. Its main function would appear to be to give strength to these parts. In the other portions of the tree it is present in smaller quantities but it forms 2·2 per cent. of the total dry matter and 17·7 per cent. of the ash, so that it is a highly important constituent of the plant.

Judging from the composition of the tree as summarized below in Table V it would therefore appear that potash and lime are the chief substances of manurial importance likely to be required, while phosphoric acid is utilized in small quantities only.

TABLE V.

Composition of plantain tree.

	Grm.
Moisture	76,797
Dry matter	10,979
TOTAL WEIGHT OF TREE	87,776

	Grm.
Potash (K_2O)	437·0
Silica (SiO_2)	241·7
Lime (CaO)	141·0
Nitrogen	111·5
Magnesia (MgO)	77·6
Phosphoric acid (P_2O_5)	46·9

Our thanks are due to the Deputy Director of Agriculture, Cocanada, who kindly arranged for the supply of the tree and for the weighing of the fresh material.

SELECTED ARTICLES

THE PRINCIPLES OF AGRICULTURAL EXPERIMENTS.*

BY

SIR DANIEL HALL, K.C.B., F.R.S.,

Chief Scientific Adviser to the British Ministry of Agriculture and Fisheries.

THE particular point to which I am going to address myself can best be phrased in the famous introduction to one of Bacon's Essays : " What is Truth." How are we going to get at truth in our experiments ? We find that we have to examine our experiments very carefully before they will yield us truth. In agriculture we have particularly tried to arrive at results by experiments, and one of the earliest forms which our experiments have taken has been to try and show upon the land how much better one variety of a farm crop, like wheat, may be than another, or how much better one treatment—be it by manure or by cultivation—may be than another, by putting down plots, side by side. We have the replica of the plot experiment when we come to examine questions of feeding. We have been accustomed to put a certain number of pigs or bullocks on one kind of diet and compare their rate of increase with that on another kind of diet. It will be familiar to many that the results obtained by this method of putting down plots and measuring the weights of their crops, are rather apt to be disappointing and sometimes confusing, for when we design the experiment we have a pretty clear idea of what the results ought to be, and yet the results have often not come out right. Various devices have been adopted by myself and my colleagues for camouflaging those kinds of results. Sometimes we have tried to explain them away, and given reasons for their occurrence. We have not always realized, I think, that those irregular results, as we might call them, were only to be expected. The present conference has been called to deal with this point. The central idea that I want you to perceive is that error is a normal circumstance of human life. We must accept this error but we can discount it and we can reduce it to reasonable dimensions. The necessity of taking error into account arises from the fact that we are dealing, in agriculture, with living organisms, either plants or animals, and they are susceptible to an amount of variability that does not appertain to steel or iron or materials of that description. Even in the study of these latter materials we have to expect errors, and make allowances for

* Discourse delivered at the Conference of Agricultural Organizers at Oxford, April 1925. Reprinted from the *Jour. of the Ministry of Agriculture*, Vol. XXXII, Pt. 3, pp. 202-210.

them, but in agricultural work, simply because we are dealing with living organisms, we have to expect much wider margins of error and take precautions to deal with them.

This error is inherent in all our work, and conclusions can only be reached from our experiments by submitting our results to a more or less statistical review. We want to get, as it were, the statistical frame of mind, and when I say that I mean something of this kind. We say, for instance, that men are taller than women. Well, that is true, statistically, but it has nothing to do with the fact that a particular man—any odd man you may meet in the street at any odd moment—may not be so tall as the next woman you meet. You have to take a certain number or "sample" of men and a "sample" of women, and these samples must be fairly large and taken without any bias, before you can verify the conclusion that men are taller than women. There is no certainty about particular instances, and, moreover, you may easily deceive yourself if the sample upon which you try to found your conclusion is not a true sample but badly selected. That is the kind of view which we have always to take into account, that before you arrive at your conclusion where material varies you have to make sure that you are reviewing a big enough sample and an honest one.

Casual error.

Now let me come back to the important point of the question of the yields from plots. I can best illustrate my point by an examination of the records of some of our oldest experiments, the Rothamsted experiments. We may take a couple of plots on the barley field, plots that are fully manured, the only difference being that one has nitrate of soda and the other sulphate of ammonia. Now it happens that on the particular Rothamsted soil, on that particular field (well supplied with carbonate of lime), and for the barley crop these two sources of fertility are practically equivalent to one another. If we take the average results of those two plots in comparison with one another over the period of 70 years we shall find that the superiority of the nitrate of soda plot over the sulphate of ammonia plot is only in the order of 1 per cent. It is no more than just perceptible. Suppose, however, that we look at the individual years, we then begin to find that the yields from these plots are very irregular. There are times when one plot is better than the other, and sometimes the reverse. One method of comparison is to take the mean of yields of the two plots and express the yields of one or other in individual years as percentages of those means. Well, if I take the very first three years I find the yields differ as follows :—

Plot 1	*Plot 2*
95	105
92½	107½
99	101

There are these great differences at the outset between plots whose average yields are practically identical. Other years in which there were great differences between the two plots gave the following comparisons :—

Plot 1	*Plot 2*
89	111
112	88
97	113

This phenomenon may be traced through all the Rothamsted experiments in which the same treatment is repeated year after year, upon the same land, and where the very greatest care has been taken to avoid mechanical errors. In the case of the grass plots you may find in any year that a plot may vary by 20 per cent. from the position you would expect it to occupy relative to the others. You must take that as a general phenomenon attaching to the very nature of the work which we are trying to do. You might, of course, look very intimately into the circumstances of any particular year and you might perhaps find some reason for the abnormality—some effect of weather, subsoil, disease, etc., which was reflected on one plot and not on the other. These variables are so numerous and so irregular in their action that you can only give a probability that a certain result will be obtained in a particular year.

Suppose we look at another type of experiment. I would ask you to study rather carefully some figures which were set out in the " Journal of Agricultural Science " about 1911. About that time two papers were published, one by Professor Wood and Mr. Stratton[1] and one by Mr. Mercer and myself[2], both of which attack the same problem but from a rather different angle. The plan we adopted was to take a normal, fairly uniform, crop sown on a uniform field in the ordinary way of business, and to divide that crop up into a series of plots. We weighed the yield of each of those plots with as great accuracy as we could. Two of the experiments dealt with the growth of mangolds, and one with wheat (at Rothamsted). The mangold field was divided into two-hundredths of an acre, and the roots and leaves were weighed separately. In the case of wheat an acre was divided into 500 separate plots. The grain from each plot was threshed out and the grain and the straw were weighed separately. The average weight of the mangold crop in the 1/200th acre plot was of the order of 360 to 370 lb., but we got a weight as high in one case as 384 lb. and as low in another case as 267 lb. The variation in yields may be illustrated by the following weights of adjoining plots

[1] Vol. III, Pt. 4, December 1910, p. 417.
[2] Vol. IV, Pt. 2, October 1911, p. 107.

"across" the field: 376, 371, 355, 356, 335, 332 lb., and the following weights of adjoining plots "down" the field: 376, 316, 326, 317, 321, 335, 341 lb. A close examination of the trend of the weights did show that the yields might be a little better on one side of the field than the other, but there was no great difference from top to bottom of the field. There was irregular variability which could not be assigned to any cause. A little group of plots gave yields of 324, 316, 342, 300, 286, 330, 317, 295, 308 lb. In close juxtaposition yields as high as 342 and as low as 286 lb. were obtained. The same results were obtained from still smaller plots on the wheat field. The variation in these cases was as follows. The average weight of grain per plot was about 4 lb., but individual yields as high as 5·16 lb. and as low as 2·73 lb. were obtained. These were variations of 30 per cent. on either side of the average.

The objection may be raised that variations of the kind were to be expected in dealing with that acre of land or that errors were introduced as a result of the small size of the plots. There was nothing to indicate in the look of the fields that they were irregular. The areas in both cases were picked out as seeming by eye to be very uniform. I would like to digress here to ask if you have ever tried to consider what kind of differences in crops you can estimate by eye. We had a very good chance of testing this point at Rothamsted. We made a practice of asking farmers well accustomed to judge to estimate the differences in yields between plots on the Little Hoos field and of comparing these estimates later with the actual yields. As a result we came to the conclusion that it was practically impossible to detect by eye differences of less than 20 per cent. in yields. Only differences of this order came to the eye, so that when a difference of 5 per cent. was estimated by the eye it was actually 25 per cent. It was very difficult to detect differences in root crops, because a small difference in diameter makes a large difference in weight of root. Psychologists have told me that it is a general law that if by your judgment alone you are going to sort out things into a series of classes you cannot make more than five such classes, *e.g.*, very good, good, middling, bad, very bad.

Now let us come back to the mangold and wheat plots. We wanted to see if there was any fundamental source of error affecting the results, that is whether the variations were of a "normal" or an "abnormal" character. Now we might take another set of numbers instead of these results. Suppose you want to find the kind of variation in the weight of something that grows naturally? We used to speak of the weight of a barley corn as a unit of weight, but if you examine a thousand barley grains you find the same kind of variation of which I am speaking, you get a lot of grain falling about the mean in weight, but a few varying widely from the "legal" barley grain in weight. How should we proceed to examine this variation? This first thing is to throw your material into a curve, and see how far that curve agrees with the "normal curve of error." You must classify your figures into groups. We can class the mangold weights into groups by every 10 lb. Our lowest weight was about 280 lb, We find the numbers of results falling into

the groups 280-289 lb., 290-299 lb. etc., and plot a curve of the results in the following way.

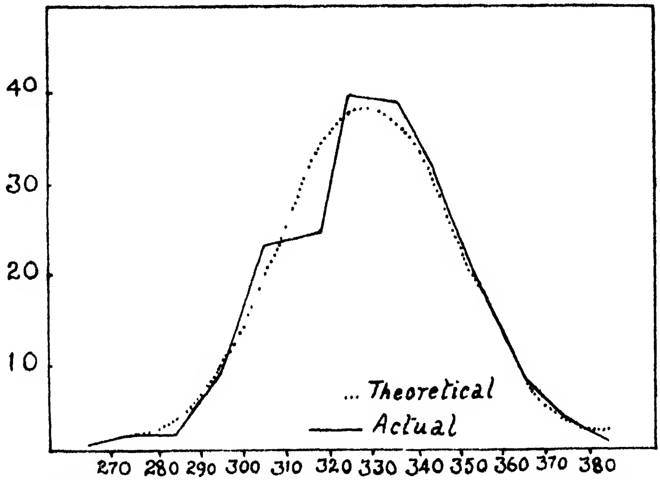

FIG. 1. Frequency curve for 200 plots of mangold roots ; actual and theoretical.

This curve approximates closely to the normal curve of error or frequency curve which is shown in the above figure by a dotted line.

A curve approximating to this shape at once gives us the information that we are dealing with uniform material, that our sample is a proper one and that our variations are casual. You may sometimes find your curve not one of this description. You may find that the curve is not symmetrical on both sides of the apex, in which case your material is not homogenous or you may get two peaks, which shows mixed material, the curve being the resultant of two curves, each with peaks of its own. In the case of the mangold and wheat plots we were therefore able to satisfy ourselves that we were dealing with quite uniform material. You can find just the same kind of thing if you take a very large number of beans and sort them out by weights. With such material, if you tabulate deviations from the mean they will always fall into a curve of this description. This is a test that your material is uniform.

METHOD OF FINDING PROBABLE ERROR.

Now how are we to get at truth in our experimental work ? We cannot have in our ordinary experimental work 200 or 500 plots. We have to know how small a number it is safe to deal with. We therefore apply a further test to our experiment. We ought to be able to calculate out our expectancies, our belief, in the results. We know results are subject to error, but how big is that error likely to be ? Mathe-

maticians have adopted a method by which the probable error can be calculated when there are a number of experiments. The actual process is a very simple one; find the mean of results, find the difference of each result from the mean; square each difference; add the squares of the differences; divide by one less than the number of results; find the square root of that result; and that gives what is called the "standard deviation." Two-thirds (or 0·6745) of that standard deviation gives what we call the "probable error." By the probable error we mean that it is even betting whether any result falls inside or outside the probable error on either side of the mean. That is the treatment which every scientific man doing experiments wants to arrive at. Suppose in a comparison of Yeoman wheat with Squarehead's Master in a 10 plot experiment the mean yield of Yeoman was (say) 103·4 per cent. of that of Squarehead's Master, with a probable error of 2 per cent. This would mean that it is even betting that the real difference between the two is something more than 1·4 per cent. and something less than 5·4 per cent. The difference per cent. between the two is less than twice the probable error. That means that we must not bet on our results. We want to get the probability of our result large enough to make it safe to trust it. We can accept our results when our difference is at least three times the probable error. Even this, of course, is not a certainty.

Let us come back to consideration of our plots. We find, on examination, that we must expect differences of at least 10 per cent. and possibly 20 per cent. between plots that should be alike. We have to keep this at the back of our minds when we are designing our experiments. and when we are interpreting them. It is no good designing an experiment if the expected differences are less than the probable error. If the probable error is of the order of 10 per cent. then it is useless to put down an experiment to show that the superiority of A over B is 10 per cent. or not much over. Now in a great number of our agricultural experiments we cannot expect a 10 per cent. difference of yield. We are all familiar with the hundreds of experiments up and down the country, designed to compare the relative values of sulphate of ammonia and nitrate of soda as fertilizers. What good is there in putting down two such plots side by side when we know that the largest difference that we can expect in the results is only of the same magnitude as the error that we must expect in such plots? In the same way, suppose we are dealing with cereals, and are going to try to compare some of the well-known varieties; we do not expect very large differences between varieties—they do not exist. A 10 per cent. superiority of one over another is rather an outstanding difference. It will probably be more like 5 per cent. or 3 per cent. A pair of plots side by side is much too coarse a measuring machine to measure such a superiority. The casual variability is necessarily greater and no amount of skill and care on our part can reduce or obliterate it.

That is the kind of statistical idea which I think every organizer, every experimenter, has got to have at the back of his mind. He must have, first of all, in designing an experiment, an idea what degree of accuracy will be required and next how

to design his experiment so as to measure to this degree of accuracy. Plots, however, can be useful for demonstration purposes when they are of no value as measures, and we must be clear at the outset which of the two purposes they are going to serve. In designing your experiment do not ask your experimental plots a question which is too subtle. In presenting your results give an indication of the degree of confidence that can be attached to them. You do not want to tell the farmer about probable errors, but you must give him the odds on or the odds against these results being true and worth adopting in his own practice.

UNIFORMITY OF MATERIAL.

Variety tests. I now turn to other pitfalls in experimental work. It is necessary to inquire into the uniformity of material and the origin of material, especially that used in variety tests. You may be putting down plots to compare varieties of wheat or of barley. Now the place of the origin of the seed, and the conditions under which it was harvested, make a good deal of difference to the yield, and if we are going to get our variety trials sound we have not to send for seed to a seedsman and trust to it being reasonably uniform material. We must really make an effort to see that we are getting the same stocks on all our plots, grown and harvested under the same conditions the previous year. Again, when we are dealing with variety tests we have to be extraordinarily careful that the varieties agree with the names under which we are testing. I remember barley trials in particular where the varieties were wrongly named. This caution is much needed now that trials with market-garden crops are beginning to become general. Different seedsmen give the same name to entirely different stocks. Variety testing will have to be carried out in more specialized fashion in future than in the past. Some of us have tried to tabulate the results of county and college experiments with varieties, but the mass of results examined have never seemed to lend themselves to such treatment. We came to the conclusion that the great mass of the work, while useful as demonstrations, had no value whatever as measures.

So impressed have we been of late by the fact that the ordinary plot experiment that we can put down at a farm, or even at a college, or institute farm, is subject to so large an experimental error that we are setting up some six centres where we will really get very elaborate and careful measures of the standard English varieties of our farm crops. The experimental methods at these centres will be fully dealt with by Mr. W. H. Parker later on during this Conference. I may say, however, that a special drill is divided into two so that it sows two varieties side by side. The drill turns back at the end of the row so that the rows across the field are A, B, B, A, A, B, B, etc. Everybody knows that in experimental plots the outside plants are taller than those inside, because they have more space, air and water, and so forth. In these experimental plots, therefore, the outside rows are disregarded, and only the centre ones measured. In this way we can hope to reduce the experimental

error to something in the order of between 1 and 2 per cent. That is to say that for that particular soil and for that season, the two varieties can be compared with an accuracy of between 1 per cent. and 2 per cent. Well, we hope to carry on the experiments with particular varieties for at least three seasons at each of the six stations, and to set out the relative merits of the varieties with an accuracy of 1 per cent. When it has been shown that a new barley or wheat variety has a valid claim to be, we will say, 10 per cent. better than another variety, I trust that agricultural organizers will carry on the work by organizing a complementary system of demonstrations. As regards demonstrations it is not worth while putting farmers to the trouble of carrying out strip or plot work ; the demonstrations should be on half fields. These are much more impressive to the farmer ; and points such as differences in standing capacity are brought out much better.

In all this work the Ministry appeals very strongly for the utmost co-operation between research stations, advisory officers and agricultural organizers. This is an example of the co-operation we hope to get between all branches of the research, advisory, and educational service. The agricultural organizer cannot ask the farmer to do the measurement work ; this can be done by headquarters, and the organizer can pick up the results and ask farmers to do large scale demonstrations.

I conclude by reiterating that we must not expect to get absolute truth ; what we can do is to collect sufficient particulars to be able to arrive at a result which is true as a whole though it may be contradicted by parts of the whole.

MILLETS FOR FODDER ON SUGAR ESTATES.*

BY

C. A. BARBER, C.I.E., Sc.D., F.L.S.

Attention was recently drawn to the importance of improving fodder supplies on sugar estates, and it was suggested that lessons might be learnt from the indigenous dry-farming practised in the East, where with scanty supplies of water and on comparatively poor soil large quantities of food and fodder were habitually grown in the struggle for existence. Millets are the main crop in such dry regions and it is estimated that one-third of the population of the world is interested in their cultivation. As an accessory fodder and food crop some form of millet is probably far and away the most economical and productive. But these crops are little known in sugar growing countries, and it is with the idea of placing the facts dispassionately before planters that the present study has been prepared. After a few remarks on millets in general, it is proposed to deal with one of them as a type and then add notes on the others as occasion may arise.

The millets occupy a very distinct place in tropical agriculture; they are the indigenous dry-land cereals of the tropics, and especially of the Old World. Maize generally takes their place in the New World, but this is essentially a sub-tropical staple; wheat, barley and oats are temperate cereals, and when they penetrate into the tropics they are generally grown on the outskirts, as in Northern India, or in elevated tracts where the climate is not tropical, and then only in the "cold" weather: rice is of course tropical, but it is a wet land crop and the whole methods of its cultivation are entirely special and different from those in crops that are rain-fed.

As is the case with all these crops, millets are occasionally irrigated, especially in tracts with a well developed agricultural practice, during the dry periods of the year, and very much greater yields are then obtained. But they are essentially rain-fed; they are, all of them, markedly drought resistant, and, maturing quickly, can be grown without irrigation in very dry tracts, where the rains come at only one time of the year: they mature in from three to five months and are thus quite common in regions with less than 20 in. annual rainfall or what are termed semi-arid countries.

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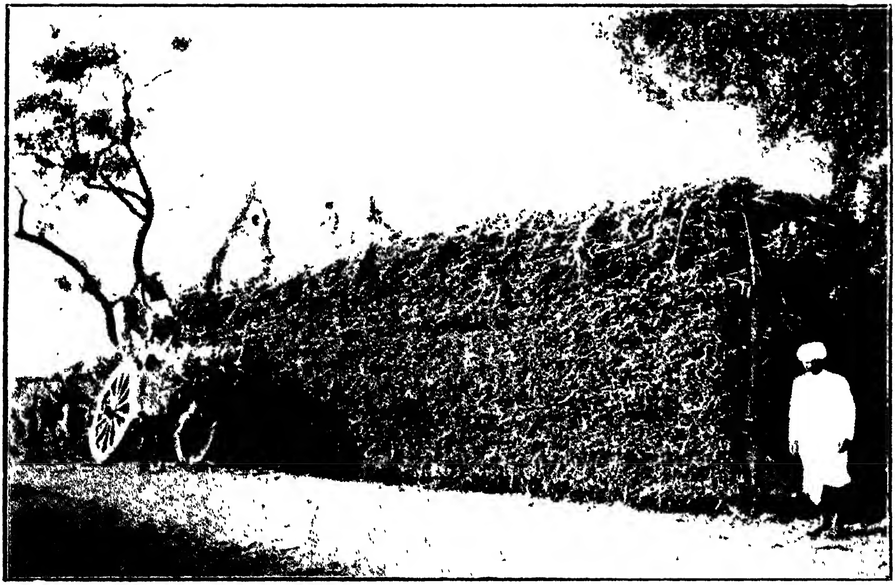
* Reprinted from *Int. Sugar Journal*, XXII, pp. 613-616.

A Moderate Field of Sorghum in Madras.



A Stack of Sorghum Straw for Cattle Fodder.

Just as wheat penetrates into the tropics and rice into the temperate regions, so the millets sometimes stray outside their tropical limits, and this is the case especially with the Italian or Hungarian millet (*Setaria italica*) which may be found from Europe to the Cape Colony, and may be seen in English botanical gardens in the summer, but this species is more adaptable than the rest.

They all of them have small grains, the giant among them, which will form the subject of this article, *Andropogon Sorghum,* having grains little over one-eighth of an inch in diameter; they may be generally distinguished by their rounded grains and are best known in this country as fowl food or bird seed. In the tropics they form the staple food of the people in the interior, where water is not available for rice growing; they are equally useful for fodder and for cattle and for human consumption; but, as they are only grown for local use, they do not enter largely into export trade.

They form the heart of the dry-land cultivation in Africa, and in Asia are specially developed in India, China, and Japan; there are 40,000,000 acres under millets in India, and the outturn in Japan is given as 35,000,000 bushels every year. They occur where the most primitive and yet intensive dry-farming in the world exists, and their cultivation is therefore associated with old-world simple implements, and they are grown in rotation or as mixtures with pulses, cotton, tobacco and a number of non-irrigated tropical crops.

Sorghum has been selected for detailed study because it is the most important millet; its agricultural needs are greater than some of the smaller forms, but it can be grown like the rest under unpropitious conditions, while with careful treatment it is capable of a comparatively enormous production as a cereal. It has thus a very wide range of usefulness.

It is chiefly grown for food and fodder, but in America, where it has been introduced from the East, there are forms which are specially adapted for producing sugar syrup and others for making brooms (hence the names "sweet Sorghum" and "broom corn"). This millet can produce great yields under favourable conditions: it is credited with giving "ten times the outturn of most cereals." The grain is an excellent food for man, the stalks are carefully stacked for fodder, and can also be used for fuel if thus required. In the New World it is chiefly grown for fodder, but for grain in the Old World, although it is always used there as a fodder too. The grain is used for cattle and horses, for fattening pigs and for poultry. Sugar is exuded from lesions in the stems and leaves and, as stated, special forms have been developed which produce excellent syrups from the juicy stems.

There is considerable doubt as to the place of origin of Sorghum: it has many wild relatives and is widely scattered in the indigenous cultivation of Africa, India and China. Most probably it was first used in tropcal Africa, was thence passed through Egypt to India, and from India to China and Japan; its introduction into the New World is comparatively recent, possibly through the slaves from Africa, as these are known to have brought many of their home plants with them. In

India alone have we accurate information as to its distribution : the average acreage for the past seven years was 21,166,166. Bombay has 7,000,000, Madras 5,000,000, the Central Provinces 4,000,000 : thus the Peninsula has two-thirds of the whole, and this emphasizes its tropical nature. In North India its substitutes are maize, wheat and another millet, *Pennisetum typhoideum*.

Botanically, it is a tufted grass, but as grown the stalks are few : this is of advantage as ensuring even ripening, a matter of great importance at the harvest. It is the largest cereal. Because of the mode of growth, usually stems with single heads, there is little separation between the branching and flowering stages which characterize the growth of all grasses. The heads of panicles vary greatly in size and form. When grown for grain, the close round or oval head is preferred, but the open panicle when it is purely a fodder crop. The "irungu cholams" of South India appear to be ideal as a fodder crop, and seed should be obtainable of all varieties by application to the Department of Agriculture in Madras. There are sometimes curious forms, such as the one in which the flower stalk bends down so that the head hangs downwards ; it is difficult to trace the origin of this, but it is of advantage as a protection against birds, as they can obtain no foothold. There are two kinds of flowers, sessile which are fertile, and stalked which are sterile. The flowers are proterogynous, that is, the female organs ripen first ; this necessitates cross pollination and the plant is wind-fertilized, a fact which is of some importance as regards the crop. If, for instance, heavy rains occur at the time of flowering, the yield will be very seriously affected. This is a point to be borne in mind with all the millets and it influences some of the others to a greater extent than Sorghum. The grains are large for a millet, as already noted. In Bombay there is a variety which has double grains. The glumes, or chaffy outer scales of the grain, vary greatly in colour so that we have black, brown, red, yellow, white and spotted grains, by which differences many of the varieties are most easily recognized. The leaves are broad, like those of maize, two-ranked, wavy, edged, with hyaline ciliated ligule, the little membranous protrusion at the junction of leaf-sheath and leaf. The roots are surface feeding, varying in depth according to soil and moisture, *i.e.*, as to whether it is grown as a wet or dry crop. Besides the ordinary soil roots, it possesses a series of aërial roots, which spring from the lower joints above ground ; these roots are strong and bend outwards and downwards into the soil where they branch, thus holding the tall plant erect after the manner of tent ropes. A true classification is at present impossible, because of the mixed nature of the fields where crossing has proceeded for ages unchecked. The colour of the glumes is a useful character, dry, pithy and juicy, sweet stalks, habit and especially shape of the head, agricultural requirements as to soil and water, length of growing period, drought resistance and so on, all are of assistance in determining the different kinds. It is interesting in this connexion to connect the kinds of Sorghum grown with the local races of people : when a native migrates, he takes a few of his own seeds with him, for he finds that the kinds met with do not suit his palate or digestion, and the appearance of a strange form of

Sorghum in the fields will often lead to the discovery that such a migration has taken place.

As to environment, all will depend on the character of the rains. Sorghum often experiences conditions which would destroy ordinary cereals such as maize. There must be free drainage, for it will not bear any standing water. Here maize has the advantage, for the writer has seen the crop reaped from boats, where the plants at crop time were under six feet of water. Sorghum has a remarkable power, which is not shared by maize, of remaining quiescent during periods of drought and immediately recovering with a shower of rain. Experiments made in the Great Central Plains region of the United States have shown that Sorghum and bullrush millet require less rain to produce a ton of hay than any other cereal tried. The cultivation of Sorghum is often a triumph of man over nature, both in North Africa and in the east, by taking advantage of casual showers which would be of no use to any other crop but a millet. The Tamil proverb runs: "if you have little to eat, sow *cholam*."

The preparation of the land and cultivation are simplicity itself. Sorghum can be grown on very poor land but of course the yield will be affected in such a large plant: it grows best in deep red loam where a height of 12-16 ft. is not uncommon, and black soil also seems to suit it very well. Such manure as is available is heaped in the dry weather and the land is cleared of deep rooting grasses: on the first showers the land is ploughed repeatedly by the simple Indian ploughs, and two or three weedings are needed and, if planted in rows, harrowings to keep the surface mulch of soil. There may be all stages from the most primitive to the most advanced dry-farming.

Sowing varies greatly according to conditions, from two to three seeds in a shallow hole, broadcasting against a basket, or drilling. The rate varies according to whether it is grown for grain or green fodder, as well as the kind of soil, etc. Four to ten times as much seed is sown for green fodder, as then the stems are as close as in a field of wheat: when grown for grain the plants are thinned when 6-8 in. high so that they are about a foot apart each way: 10-15 lb. per acre should be sufficient for a crop intended for grain and straw, 40-100 lb. when it is intended for green fodder. Sorghum is often sown as a mixed crop with legumes, and the most various mixtures are in vogue in India. To give an example: five crops are sometimes sown together: cucumbers will ripen in six weeks, cow peas in three months, Sorghum in four months, red grass (pigeon-pea or *Cajanus indicus*) in seven months and, when the latter is reaped, the whole field will be covered by it and no trace left that any other crop has been grown. The time of sowing depends on the incidence of the rains, not heavy rains but occasional showers; this is extremely important in dry tracts, and is forcibly expressed by another Tamil proverb, "if the time of sowing is missed *cholam* will not grow if it is sown on a dunghill."

The best method of reaping is to cut the field and lay the plants spread out on the ground for four days, then raise them in cocks for a month to allow the im-

mature grains to harden; then thresh and heap the straw into great ricks. This straw will keep for the best part of a year and provides good fodder for cattle. If raised for green fodder it may be cut as required, the best food value being obtained when the flowers are beginning to set seed: or the whole may be cut and stacked in a rick, after a little wilting, the stalks being laid with the heads inwards.

The yield depends of course on conditions, and there may be from 100 to 500 to 1500 lb. of grain: if grown for fodder anything up to 25 tons may be harvested. It is a common practice to ratoon the crop for a time, as the stalks left will send out many shoots. But this requires some care and should not be attempted by novices. The young foliage if poorly grown develops a deadly poison, but this does not occur if there are rains or the soil is moist and the growth free. Such ratooned Sorghum forms excellent grazing for the cattle.

The crop has its own diseases and pests which are far too numerous even to catalogue in detail. All insects, all birds, many beasts together with fungi and even small parasitic flowering plants. In growing crops, aphides, mites, ear moths, stem and shoot borers, smuts, rusts, protozoa, moulds: also seeds germinating on the plant in wet weather, low lying places and alkaline spots should be guarded against: as stored grain the usual grain pests will also be met with. There is no space to speak of the value of the grain as food, but it may be mentioned that both grain and flour keep well because of the comparatively little water and oil that they contain. Bread cannot be made from it as it will not form loaves, but as cakes and porridge it is excellent, once the somewhat peculiar flavour is mastered.

NOTES

THE BOARD OF AGRICULTURE IN INDIA.

THE Fourteenth Meeting of the Board of Agriculture in India will be held at Pusa from the 7th to the 12th December, 1925, when the following subjects will be discussed :—

(1) (*a*) To review the progress made by the Central and Provincial Governments and by Indian States since the last meeting of the Board of Agriculture in developing animal husbandry and dairying, and to make recommendations.

(*b*) To review the results obtained and experience gained in making silage in India, and to make recommendations.

(*c*) To consider to what extent Provincial Governments and Indian States can co-operate with the Central Cattle Bureau in the formation of pedigree herds of Indian cattle, and in the control of pedigree records.

(*d*) To consider the extent to which Co-operative Departments can co-operate with Agricultural and Veterinary Departments in the development of cattle-breeding and dairying.

(*e*) To consider what further steps can now be taken by Government to combat outbreaks of cattle disease and particularly to set up a permanent immunity against rinderpest amongst susceptible animals by the application of the serum-simultaneous method of preventive inoculation.

(*f*) To consider whether the time has now come for Provincial Governments and Indian States to train men for the Indian Dairy Diploma of the Imperial Institute of Animal Husbandry and Dairying.

(2) To consider what steps should be taken for the improvement of Indian tobacco.

(3) Agricultural middle schools—A discussion on the progress made and experience gained since 1922.

(4) What steps can be taken to save crops from the depredations of wild animals ?

(5) To consider the desirability of establishing closer relations with the International Institute of Agriculture at Rome, and to discuss the agenda of the General Assembly of the Institute for 1926.

JAVA SUGAR CROPS.

"The International Sugar Journal" for July 1925 publishes an article showing the area devoted to sugarcane in Java together with the production of cane and of sugar for the last ten years, *i.e.*, from 1914 to 1924 inclusive. As these figures are very instructive we give them hereunder in acres and tons for the convenience of readers in India.

Year	Area in acres	Cane per acre in tons	Sugar per acre in tons	Rendement	Total sugar in tons
1910	312,600	39·03	4·03	10·33	1,258,287
1911	335,600	41·94	4 29	10·26	1,443,465
1912	346,800	41·53	3·98	9·63	1,384,242
1913	359,200	41·63	4 07	9·65	1,442,884
1914	366,000	40·87	3·79	9·28	1,382,825
1915	373,500	37·97	3·48	9·15	1,298,307
1916	385,290	41·11	4·12	10·03	1,604,154
1917	396,440	43·09	4·52	10·50	1,793,415
1918	402,943	38·44	4·34	11·19	1,750,197
1919	340,138	38·10	3·86	10·06	1,315,158
1920	385,647	37·34	3·94	10·55	1,519,562
1921	394,060	37·89	4·16	11·04	1,658,032
1922	397,443	42·05	4·44	10 61	1,[illegible]79,557
1923	401,485	40·04	4·37	10·97	1,764,636
1924	424,945	42·36	4·61	10·88	1,966,237

This table shows that from only 425,000 acres under cane Java manufactures nearly two million tons of sugar, while India with 2,700,000 acres under cane manufactures 2,700,000 tons of *gur** and as not more than 40 tons of sugar are on an average made from 100 tons of *gur* by Indian refineries, it comes to 1,080,000 tons of sugar, if the whole were converted into refined sugar; and this works out at 0·40 ton refined sugar per acre against the average of 4·60 tons of sugar per acre in Java. The highest average yield of sugar per acre in Java was obtained in the district of Djokjaakarta where 6·38 tons of sugar were made per acre in 1924, while one factory

* This is exclusive of refined sugar made direct from cane in modern factories. The highest production of this grade of sugar in India has not yet exceeded 39,000 tons.

which showed the highest output of sugar per acre in Java reached 7·186 tons of sugar per acre.

The results no doubt are staggering to those in India but they are the product of a favourable climate, the go-ahead policy of the Dutch planters and an efficient and well-organized scientific service for experiment both in field and laboratory and control in mills. As an instance, we may mention the fact that the older varieties P.O.J. 100 and B. 247 are now rapidly being replaced by the new varieties E.K. 28 and D.I. 52, and as these are thick canes of heavier tonnage and good sucrose content, the yields per acre will continue to show improvement.

What have we got in India to show *as our progress during the last fifteen years?* We established our Cane Breeding Station in October 1912 and it has done valuable work in evolving new seedlings. Some of these, *viz.*, Co. 210, 213 and 214, have been found to be superior to local varieties in the white sugar tract of North India and are now being grown on over 5,000 acres. On an average, these seedlings yield about 25 tons of cane per acre as against 10 tons of local canes and they are very suitable for the factory. In the Punjab, on the other hand, Co. 205, which is essentially a cane suited for *gur*-making, is being grown on a large scale. Even then the progress made is very poor when compared with that made in Java. [WYNNE SAYER.]

EMPIRE COTTON RESEARCH STATION.

THE Executive Committee of the Empire Cotton Growing Corporation have adopted the recommendations made by Professor J. B. Farmer and Mr. L. G. Killby in the matter of the foundation of a Cotton Experiment Station for the British Empire, and steps are being taken to establish the Research Station in Trinidad. The announcement, together with the report by Professor Farmer and Mr. Killby, causes no surprise that Dr. Balls, in a " foreword " to the report, confesses that he felt himself to be a visionary when some such scheme came to his mind in 1911. That the series of events which included the formation of the Empire Cotton Growing Corporation and the British Cotton Industry Research Association would also include the establishment of a cotton research station in Trinidad, or elsewhere within the Empire, could not readily have been prophesied by anyone, and Dr. Balls rightly testifies his appreciation that his Utopia has materialized. For an industry reared on " rule of thumb " and nurtured on " what was good enough for my father is good enough for me," the establishment of three such organizations as those above mentioned may be regarded as an exhibition of faith that has indeed " moved mountains." Quotation from the report itself can best indicate the *raison d'etre* of the research station. " There are many fundamental problems connected with the cotton plant and with the properties of its lint, the investigation of which does not fall within the duties of the scientific specialists on the agricultural staff of any single cotton-growing country who have not, moreover, as a rule, had the

requisite training to fit them for such work, nor have they the time to do it if they had. Since, however, the successful solution of such problems may be confidently expected to lead to results of the highest value to the cotton industry, the Corporation intend to establish a Central Research Station, whose special function shall be the study of such problems rather than the investigation of local difficulties which in most instances can better be studied in the country in which they originate. Prior to recommending the establishment of one central station the Corporation considered very carefully the possible alternative of subsidizing institutions in different parts of the Empire to carry out research work on the cotton plant. The reasons which led them to reject this alternative were briefly as follows; if the work is not concentrated at a central station it is impossible to focus it on a common line of attack on any particular problem, nor can there be effective co-operation between the different branches, *e.g.*, genetics and physiology. Secondly, results and records would be scattered, thus making continuity of record impossible and reference by other workers difficult. Thirdly, there would be no one recognized place to which problems could be referred for investigation from the different parts of the Empire, and there would be no possibility of ascertaining the precise conditions under which any particular result was obtained, and of repeating those conditions in another experiment, whereas these would be standardized and recorded if there were only one central station." The report then goes on to examine the determining factors by which their choice of a site for a central station should be governed, and having decided upon a closer examination of the advantages and disadvantages of Trinidad it records these pros. and cons. in detail. The advice given as to the starting point at which work may early be begun and as to the staff suggested for such work, shows a clear appreciation of the real functions of the station and of the fundamentals of all its work. In respect of what may be expected by the ultra-optimistic or by those who seem to imagine scientific investigation is the "open sesame" to immediate financial gain of a hitherto unprecedented character, a further quotation from the report must be made. "It may be regarded as certain that an Experiment Station founded to deal with the cotton plant cannot expect to exhaust, within a short period, the wide range of problems that demand solution"; and again, "Botanical research, owing to the nature of its material—the growing plant—is not a rapid process and, for the same reason, cannot be expedited." Lastly, the report not only states that "foresight should indicate the need from the beginning of providing that its later activities should not be cramped by lack of space for future extension," but shows clearly that such foresight has been exercised and that, down to questions of administration and of actual site, etc., every aspect and detail of the work has been thoroughly and appreciatively examined by the two gentlemen deputed to compile the report. The Corporation are to be heartily congratulated, not only upon the adoption of their recommendations, but upon the candid and sincere manner in which those recommendations are made. [*Jour. Textile Inst.*, XVI, pp. 235-236.]

CANE SUGAR CROP SEASONS AND PRODUCTION.

It is not only of interest, but also of considerable importance to the designing engineer to have a reasonable knowledge of the relative importance of the various countries of the world as regards cane sugar production; also of the months when crushing commences, and of the duration of the campaigns, for when sending out new machinery to cane sugar countries early delivery so as to allow time for erection before the commencement of the grinding season is always of importance. Many engineers have a few rough notes on these points, but often they are far from being complete studies of the latest data.

Cuba is well known to be a very important island as regards cane sugar production, but it is by no means always fully appreciated that Cuba provides just over one-third of the total cane sugar of the whole world; this, however, is the fact, and, since practically all the sugar made in Cuba is exported, it is the reason why the Cuban crop exercises such a predominating influence on the world's sugar market.

British India occupies second position in the list of production, and furnishes well over one-sixth of the total, but as nearly all of it is made as *gur*, and all of it is consumed locally, its importance is seldom understood.

The third, and last of the really important cane sugar countries is Java, which produces more than one-eighth of the total, most of which is exported.

It is worth noting that Cuba makes nothing but raw sugar for the refineries; British India makes *gur* (the crystal sugar produced is less than 2 per cent. of the total); and Java makes mostly "plantation whites." These three countries together provide practically two-thirds (65 per cent.) of the cane sugar of the world.

No other single country produces so much as 5 per cent. of the total: Natal and Demerara produce less than 1 per cent. each, and such places as Reunion, Jamaica, etc., do not produce even one-third of 1 per cent. each. * * * * A single (and comparatively small) factory in Cuba will turn out much more than the totality of the factories in a place like Jamaica. It is worth noting that 45 per cent. of the total cane sugar production of the world is at present more or less under the control of the United States of America.

At the present time, of the total sugar production of the world, 61 per cent. is cane, and 36 per cent. beet; and of the beet sugar, 87·7 per cent. is European, 11·9 per cent. U.S.A., and 0·4 per cent. Canadian.

Then considering the distribution of the cane sugar crop throughout the year, it is generally known that production goes on all the year round, in one country or another, but it is not always appreciated that 75 per cent. of the total is produced during the six months December-June, and only 25 per cent. during the other half-year. * * * * [P. H. Parr in *Int. Sugar Journal*, XXVII, No. 319.]

THE U. S. A. COTTON FARMERS' CO-OPERATIVE ASSOCIATIONS.

"On the occasion of last year's journey through the U. S. A. Cotton Belt, Mr. Arthur Foster and the writer reported in detail on these then recently created organizations (*Int. Cotton Bull.*, III, No. 5, pp. 8-12). I quote the paragraph of that report dealing with the method of handling cotton by the associations :—

"The farmers who become members of a co-operative organization sign a legal contract under which they agree to hand over for a period of five or seven years all their cotton for sale through the society. Though the contract has been approved by the courts it is doubtful whether a wholesale enforcement of the same would be possible. The co-operative societies have no capital at their inception, but receive advances from the banks on the cotton. On delivery of the cotton to a first class warehouse the farmer receives from the society an advance of 60 per cent. of the value of the cotton, 1 to 3 per cent. of the gross value is retained by the societies for the formation of a reserve fund, and when the cotton is actually sold the farmer receives the balance. The main advantages as regards the farmers as a class are that they receive an average price for the whole season's cotton, and that if a grower raises one single bale of a cotton superior to the rest he will receive an adequate price for the same, whilst formerly any small quantity of better grade or staple cotton had to be sold together with the bulk. The society does not own warehouses, but uses any public warehouse of good construction, and as soon as the cotton arrives there, samples are sent to the head offices, where each bale is carefully classed by expert graders in the employment of the societies. All the classing of cotton from one State is therefore done in the same room, under equal conditions. The organizations have been careful to engage the very best graders they could obtain from existing well-reputed exporters ; there are men amongst these who have specialized knowledge of the Liverpool, Havre and Bremen markets, and we have learned from private conversation with these graders and convinced ourselves that the grading is done most carefully—in fact, the instructions to the classer are to state the grade of the cotton half a grade lower than that which it represents actually. The work of these graders is to collect lots of identical cotton and make what is called a 'pool.' A careful system of book-keeping is used in each office by means of which the owner, and all other particulars relating to each bale, may be traced, and once the whole 'pool' is sold, the farmer receives the balance of the full average price due to him on his lot.

"The societies are not allowed to hold cotton back for the purpose of obtaining higher prices, but they are obliged to sell some cotton every month, regardless of price, though it will only be natural that when prices rule low they will not put large quantities on the market. In this way the farmer will obtain more or less the average price ruling throughout year, whilst formerly, as we know from experience, most farmers have rushed all their cotton on the market immediately it has been ginned. It is anticipated that the monthly sales of the co-operative

societies will finally lead to a stabilization of the price of cotton. There is no fixed quantity of cotton which has to be sold every month.

"The great advantage to the spinner is that the societies are not allowed to offer cotton except that which they have actually in their warehouse. They cannot go into the open market to fill an order. They sell on actual samples, *i.e.*, bales in warehouse, and on types made up in each season."

I have pleasure in being able to state that the development of these associations has progressed in spite of the large amount of opposition and jealousy displayed by the cotton factors, f.o.b. merchants and, to some extent, by the export merchants and local banks. Indeed, the membership has increased and over 1,000,000 bales have been dealt with during last year. This campaign against the "co-ops" must be regarded as a natural consequence, for the attacking parties recognize that their very existence is threatened by this more up-to-date commercial system. The writer recognizes in the farmers' co-operative movement a distinct evolution towards a more modern and more efficient system of cotton trading by means of which those intermediaries between the producer and consumer, who do not perform work commensurate with their toll, must get out of the long chain, and though this does not mean that *all* the exporters will go out of the cotton business, it does mean that a multitude of those who do not perform work of necessity will follow that pretty large number of firms which have been forced recently to turn their attention into other channels. The "co-ops" are the natural outcome of things. Farmers never were versed in the merchanting end; they recognized that they had been in a prejudiced position on account of this lack of knowledge and the Government helped them by sending graders to the principal cotton centres. That step led to the formation of various systems of farmers' organizations and the present "co-ops" are the outcome. Here expert marketing methods replace the farmers' previous unscientific ways. The Federal Government has recognized the advantages resulting to the farmers from these societies and has provided the following legislation by Congress largely with a view to facilitating co-operative marketing :—

(1) The Cotton Futures Act, 1914; it provided, amongst other things, the promulgation of uniform standards for grade and staple and the dissemination of cotton price information;

(2) The Warehouse Act; an important factor in obtaining credit for farmers;

(3) The Federal Reserve Banking Act; in consequence of which the financing of cotton on the basis of a trade or bankers' acceptance has become possible;

(4) The revival of the War Finance Corporation and the application of its funds to the resuscitation of agriculture, thus providing the necessary credit for financing large co-operative societies;

(5) The Capper-Volstead Act, exempting the farmers' co-operative organizations from the Sherman Anti-Trust Law ;
(6) The Cotton Standards Act, 1923.

The various States have legalized the co-operative organizations and given them support. Therefore it is evident that these bodies or at all events similar ones will continue to exert their influence. In short, the sooner it is recognized that the "co-ops" form one of those far-reaching changes that have taken place in the natural run of marketing development, the better for all parties. The cotton growing and manufacturing industry is likely to gain great benefit by co-operation, which I will try to show in the following paragraphs.

These associations are the real mouth-pieces of the cotton farmers. Hitherto the consumer has not had an authoritative body before whom he could lay his requests for reform. That has changed.

The associations have contributed already in making cotton cheaper. They have to a large extent been responsible for the very considerable reduction of country damage due to the fact that all cotton handled by them must be properly warehoused, even if only for the purpose of satisfying the banks which finance the cotton. It is natural that the whole method of financing the cotton crop through associations is bound to become cheaper as the most influential banking corporations of the whole of U. S. A. stand behind the co-operative societies, and it is because some of the local banks have lost custom that they have tried to work against them. Equally warehousing and insurance costs have already been reduced, for the cotton handled by those associations which have been able to concentrate deliveries in up-to-date warehouses such as is done in Texas and Oklahoma. It stands to reason that these rates must be cheaper for large quantities than for smaller ones. If one can offer business to an insurance company for 1,000,000 bales or for 100 bales, the rate must be in favour of the former. The "co-ops" have undoubtedly performed their task of classing cotton to the satisfaction of their clients. One of my American friends who bought cotton from one of them on my recommendation told me this year that out of 4,000 bales staple cotton he had not found, after careful examination, one single bale below the type ordered. Further, I have seen the books of several associations and can assure the members of the International Federation that the claims lodged for inferior quality have indeed been very small. It must be borne in mind that there is no firm of cotton merchants in any part of the world which has so large a quantity of its cotton from which to make up lots as the "co-ops." For that reason they are in an excellent position to deliver even running lots. Unfortunately the European selling organization of the "American Cotton Growers' Exchange", which is the name of the central sales department now established in Memphis, Tenn., has not yet had sufficient experience in coming into direct connection with the spinners in Europe, but no doubt this will follow. So far they have not been able to sell on "buyers call" owing to some regulation in their statutes.

It is not only the cotton which the spinner receives from the association that is cheaper than heretofore, but the consumer gets cotton from other sources at somewhat lower prices than he would do were the " co-ops " not in existence. The writer was told by a cotton salesman of an up-country house how they themselves and all the f. o. b. merchants were contenting themselves with half the profits they were previously accustomed to, for the purpose of undermining the position of the " co-ops", etc. Generally they explain to farmers that the charges per bale handled by the association are much higher than if the cotton passed through them. It is true that in the beginning these charges in some associations worked out pretty high but that has been changed through more concentration. One association has learned from the experience of another. These critics always forget that cotton in the ordinary way changes hands many times, and it is not only the charges and profit of one merchant, but the multiplication of these items of each firm handling the same cotton that should be taken into account. In the case of the " co-ops " there is only one charge, whilst much of the other cotton pays three and four and even more tolls.

The individual members of the associations have, on the whole, adhered loyally to the five years' contract to sell their cotton through the association. Of course, when dealing with 247,240 members there are always some malcontents to be found who try to get out of the contract by underhand means. The contract has stood the test of the law courts, but there has been no need to apply it frequently. It is true that some members have endeavoured to obtain a release, but their number is very small indeed in comparison with the new additions. It would seem that during this season the co-operative associations are likely to handle 1,500,000 bales. With the gaining of more experience on the part of the Board of Directors, consisting entirely of farmers, many of the drawbacks which have existed will, no doubt, disappear. It was only natural that these farmers having been placed at the head of huge commercial concerns, dealing with a turnover of several million pounds sterling, would commit mistakes, but on the whole they have discharged their functions remarkably well. These men are realizing that the cost of production will have to come down through the use of more scientific methods and that shows a wider range of vision than what we have been accustomed to in the past from the spokesmen of the cotton farmers in U. S. A.

It will be readily seen that these associations spread all over the Cotton Belt, can perform very useful work such as improvements in the baling of cotton, reduction of tare, distribution of boll-weevil remedies, of cotton seed, supervision of ginneries, etc.

The Staple Cotton Co-operative Association, Greenwood, Miss , does not form part of the above organization, but works on identical lines. They handle about one-third of the Delta crop which, by the by, promises to be this year very strong, much better even than last year, especially free from nep. This association has 16,000 active members. If a client buys from this association for monthly ship-

ment ahead, he receives at once samples for all future deliveries. The client sees the samples before his bank accepts the draft. During the last season this association shipped to :—

	Bales
Eastern States of U. S. A. and Canada	35,79[illegible]
Carolinas	31,738
Liverpool and Continent	28,322
Local Merchants	10,961
On hand	715
TOTAL	107,[illegible]

It may be of interest to add the classification of bales which passed through the hands of the Staple Cotton Growers' Association last year :—

American measurements—	Bales	Per cent.
$1\frac{1}{16}$ in. to $1\frac{1}{8}$ in.	5,208	4·9
$1\frac{1}{8}$ in.	18,317	17·0
$1\frac{1}{8}$ in. to $1\frac{3}{16}$ in.	36,676	34·1
$1\frac{3}{16}$ in.	27,970	26·0
$1\frac{3}{16}$ in. to $1\frac{1}{4}$ in.	12,001	11·1
$1\frac{1}{4}$ in.	2,979	2·7
TOTAL	103,151	

This will give a fair idea of the relation of the various staple lengths grown in the Delta.

The highest average price paid last year by the association to the members was 36 cents, whilst the average of the whole worked out to 32·66 cents.

The total Delta crop during the last few years was as follows :—

1922	1923	1924
Bales	Bales	Bales
502,757	506,988	[979,687

[Extracted from the *International Cotton Bulletin*, Vol. III, 2, No. 10.]

PRODUCTION OF ALCOHOL FROM NIPA PALM.

We have received the following for publication :—

The question of making an efficient motor fuel in the tropics, where imported spirit is expensive, is at present attracting considerable attention. Various materials have been suggested, and in some cases tried, as a source of power alcohol, such as starch-containing roots, and cellulosic residues from the sugar and other industries, but one of the most valuable appears to be the sap which may be collect-

ed from the flowering shoots of the Nipa palm of the Far East. Considerable work has been done in the Philippine Islands in ascertaining the suitability of this palm for the production of alcohol and quite recently an experimental plant has been erected in the State of North Borneo. The plant is being run under the direction of the local Department of Agriculture and an account of the results of the first year's working, based on a memorandum supplied by the British North Borneo Company, is given in the current number (XXIII, No. 2) of the "Bulletin of the Imperial Institute," published by Mr. John Murray.

There are about 300,000 acres of Nipa palm in North Borneo, occurring in nearly solid stands of 5,000 acres or more. The sap flows for only six months in the year, but it is estimated that during this period 900,000,000 gallons of sap, capable of producing nearly 60,000,000 gallons of alcohol, could be obtained. The results of the first year's working of the experimental plant came up to expectations in every way. The still was only capable of producing 100 gallons of alcohol per working day of 12 hours, and the costs of running such a small plant were naturally somewhat high, but it is shown that a permanent plant producing not less than 1,000 gallons per day should prove a commercial success. Estimates are quoted in the article of the cost of production for plants of various capacities. For a plant capable of producing 2,000 gallons per day of 12 hours the capital required is estimated at about £26,000, and the profits on the spirit delivered in Singapore or Hong Kong would be equivalent to a dividend of 10 per cent. on the capital. An 8,000 gallon plant run for 24 hours per day would require a capital of about £122,000, and this, it is estimated, would yield profits equivalent to 30 per cent. on the capital.

COTTON NOTE.

THROUGH the courtesy of the British Cotton Industry Research Association, the Secretary of the Indian Central Cotton Committee has sent the following abstract for publication :—

GROWTH OF COTTON PLANT.

Data are presented on the order and rate of appearance and growth of floral buds, the sequence of flowers and the growth of bolls. The studies have been made under different conditions of growth in three different areas. The records show a very close agreement in the rate of appearance of floral buds and blooms between distinct species and types of cotton grown under different conditions. Considerable variation was observed between varieties in the period of development of the floral bud and in the interval from date of flowering to boll maturation ; this indicates the importance of considering the relation of varietal and environmental factors to the growth rate. [*Jour. Agri. Res.*, 1923, **25**. 195-208. R. D. MARTIN, W. W. BALLARD and D. M. SIMPSON.]

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

MR. J. W. BHORE, C.I.E., C.B.E., I.C.S., Secretary to the Government of India in the Department of Education, Health and Lands, has been granted leave on average pay for 3 months and 22 days from 29th September, 1925, Mr. R. B. Ewbank, C.I.E., I.C.S., officiating.

MR. G. S. BAJPAI, C.B.E., I.C.S., has been appointed to officiate as Deputy Secretary to the Government of India in the Department of Education, Health and Lands, *vice* Mr. R. B. Ewbank on other duty.

MR. P. V. ISAAC, B.A., D.I.C., M.Sc., F.E.S., Second Entomologist (Dipterist), Pusa, was on leave on average pay for two months from 1st September, 1925.

MR. N. V. JOSHI, M.Sc., B.A., L.AG., First Assistant to the Imperial Agricultural Bacteriologist, Pusa, was appointed to hold charge of the current duties of the appointment of Assistant Bacteriologist, *vice* Mr. J. H. Walton granted leave for four months from 6th July, 1925.

DR. W. BURNS, Principal, Agricultural College, and Economic Botanist to Government, Bombay, has been granted combined leave for three months and seven days in continuation of the leave already granted to him.

MR. K. HEWLETT, O.B.E., M.R.C.V.S., Principal, Bombay Veterinary College, has been granted combined leave for six months and nine days from 15th June, 1926, Mr. V. R. Phadke, G.B.V.C., officiating.

MR. M. H. SOWERBY, M.R.C.V.S., Professor of Veterinary Science, Bombay Veterinary College, has been granted an extension of leave, on half average pay, for 10 months from 1st November, 1925.

MR. D. BALAKRISHNA MURTI GARU has been appointed Deputy Director of Agriculture, Sixth Circle, Madura (Madras).

ON return from leave, Mr. F. WARE, F.R.C.V.S., has been appointed Chief Superintendent, Civil Veterinary Department, Madras.

MR. P. T. SAUNDERS, O.B.E., M.R.C.V.S., will continue to act as Acting Principal, Madras Veterinary College, on relief by Mr. Ware of his duties as Acting Chief Superintendent, Civil Veterinary Department, Madras.

MR. N. S. MCGOWAN, B.A., Deputy Director of Agriculture, North Bihar Range, has been granted combined leave for two years, one month and four days from 23rd October, 1925.

MR. D. R. SETHI, M.A. B.Sc., Deputy Director of Agriculture, Orissa Circle, has been granted leave on average pay for six weeks from 3rd December, 1925.

MR. M. J. BRETT, M.R.C.V.S., on return from leave, has been posted to the Government Cattle Farm, Hissar, as an officer on training for a period of three months.

MR. P. B. RICHARDS, A.R.C.S., F.E.S., Entomologist to Government, United Provinces, has been granted combined leave for 10 months from 1st September, 1925. Mr. P. K. Dey, Plant Pathologist, has been appointed to officiate as Entomologist, in addition to his own duties.

MR. W. YOUNGMAN, B.Sc., Economic Botanist, Central Provinces, has been granted combined leave for 10 months and 26 days from 27th November, 1925, Mr. R. H. Hill officiating.

REVIEWS

A Handbook of Sericulture : I, Rearing of Silkworm.—BY M. YONEMURA, late Silk Expert, Sericultural Department, and N. RAMA RAO, Superintendent of Sericulture in Mysore. (Pp. 119+14 illustrations ; Government Branch Press, Mysore ; 1925.)

This book is the first of the series of manuals dealing with the sericultural industry. The main purpose of the book, it is mentioned in the preface, is to provide to the readers in " an easily understandable form the best and the most recent information " on silkworm rearing. It is doubtful if the book will serve this purpose. The authors have gone into the subject of rearing in considerable details. The necessity of food, air, suitable temperature and humidity have been impressed upon the reader, who has been warned against sunlight, sudden extremes of temperature, draught and too much humidity. The authors have laid special stress on rearing house equipment and apparatus for preparing leaves, but the most difficult operation, *i.e.*, incubation, has only been dealt with from a theoretical point of view. Surely it is easier to use an incubator than cool or heat a room ; and if a hygrometer can be recommended why not an incubator. Brushing, harvesting, chopping of leaves, feeding, cleaning, spraying, mounting, all receive due attention.

The chapter on silkworm diseases, if illustrated, would have been very useful.

There is much of value in the chapter dealing with grainage.

The manual is more suited for the people who wish to go in for " technical rearing " than for those who wish to undertake " commercial rearing."

There is room for much improvement in the language of the Handbook. [M.A.H.]

A Short Key to both Sexes of the Anopheline species of India, Ceylon and Malaya.—BY C. STRICKLAND, M.A., B.CH. (Calcutta and Simla : Thacker, Spink & Co.) Price, Rs. 1-12.

This key is a well written and beautifully illustrated production by one who is thoroughly conversant with the mosquito fauna of the regions concerned and equally well understands the needs of the entomologist and particularly of medical men and health officers. The characters used to distinguish the species are such as could be easily observed and would lead to accurate determination and the author's belief, as stated in his introduction, that a worker using this key to " spot " mosquitoes, although he has, in the beginning, to examine his specimens under the low power of

a microscope, could later diagnose them with any sort of simple pocket lens or even with the naked eye, is well founded.

The illustrations are very clear and the get-up is good. In referring to scientific names there are some cases of deviations in spelling such as *jamesii* on page 6 printed as *jamesi* on page 13, and *ludlowii* on page 6 as *ludlowi* on page 17, and *stephensii* on page 6 as *stephensi* on page 17—on page 13 *fuliginosus* is put down as *fuliginasus*. These errors may be rectified in a later edition in which also the succession of species listed in alphabetical order in the introduction could be improved.

The author differs to some extent from certain other authorities in what species he considers as valid. This, however, does not make much difference to the usefulness of the " key " which is cheap at the price of Rs. 1-12 and ought to be in the hands of every one who has to examine mosquitoes. [P. V. I.]

The Size and Distribution of Agricultural Holdings in the Punjab.—By H. CALVERT, B.Sc., C.I.E., I.C.S. (The Board of Economic Inquiry, Punjab —Rural Section Publication No. 4.) Price, As. 4.

This enquiry was carried out with a view to arriving at a fairly accurate estimate of the manner in which the peasant proprietors in the Punjab are grouped into classes according to the cultivated land owned. The author has attempted to deduce from the figures obtained an estimate of the manner in which the land is distributed amongst the different classes. The enquiry, which was conducted on a large scale with the help of the Revenue officials of the province, extended to 2,397 villages, comprising an area of over 2 million acres, fairly evenly distributed throughout the province. It was found that over 58 per cent. of the owners of cultivated land held less than five acres, 26 per cent. over five but under fifteen, 11 per cent. over fifteen but under fifty, while less than 4 per cent. held over fifty. Sixty per cent. of the cultivated land is held, however, in holdings of over 15 acres. With the exception of the canal colonies (which cover 3 million acres or 10 per cent. of the whole province), where there has been a definite State policy of creating peasant holdings of 25 to 27½ acres, the distribution in the rest of the province has followed natural causes. Small holdings are mostly found where the rainfall is comparatively heavy and certain: figures abstracted for tehsils along the Sutlej, the Jhelum and the Indus rivers all show the same influence of rainfall on the size of holdings.

Out of the total cultivated area of 28,820,000 acres in the province, over half is cultivated by tenants paying rent and most of these tenants are themselves owners of small areas of less than 8 acres. It appears that the larger the proportion of land held by small owners, the smaller is the proportion cultivated in the same tract by

tenants paying rent; in congested districts this proportion is as low as 35 per cent. The author is to be congratulated on his success in collecting and presenting in a readable form a large number of relevant and useful statistics bearing on the question of the size and distribution of holdings in the Punjab.

An Enquiry into Mortgages of Agricultural Land in the Kot Kapura Utar Assessment Circle of the Ferozepore District in the Punjab.—By SARDAR BALWANT SINGH, B.A. (The Board of Economic Inquiry, Punjab, Rural Section Publication No. 5.) Price, As. 6.

At the instance of the Board of Economic Inquiry, Punjab, Rural Section, an enquiry into mortgages of agricultural land in the Kot Kapura Utar Circle of the Ferozepore District in the Punjab was conducted by Sardar Balwant Singh under the general supervision of Mr. H. Calvert. The enquiry covered over 90,000 acres comprising 26 villages. Altogether 4,498 mortgage cases involving 19,373 acres of mortgaged land with a total consideration amount of Rs. 30,47,483 were examined. Of 19,373 acres of land mortgaged (23 per cent. of the cultivated area), 15,595 acres (19 per cent. of land owned) are owned by agriculturists and 3,778 (23 per cent.) by non-agriculturists; while among the mortgagees, 16,948 acres are held by agriculturists and 2,425 acres by non-agriculturists.

Since the introduction of the Punjab Alienation of Land Act, the professional money-lender has little scope left for his activities and the creditors are now mostly agriculturists themselves. The major portion of the money loaned out has thus been derived out of savings from agriculture; the basic cause for so much mortgaging would appear to be money seeking an outlet rather than the poverty of the mortgagors. In fact, every landowner with a little spare cash is ready to take the mortgage, and the sonless proprietors, who are mostly wastrels and have no intention of redeeming the land, are responsible for nearly half the mortgages. Of the total amount of mortgage consideration, 64½ per cent. was paid on account of previous debt, 13 per cent. was spent on wine, opium, gambling, etc., 6 per cent. on marriages, 1½ per cent. on litigation and only ½ per cent. for revenue and rent. The increase in the value of land has a tendency to facilitate credit and thus to swell the amount of consideration money, but the result of successive mortgages is a decrease in the area mortgaged.

NEW BOOKS

On Agriculture and Allied Subjects

1. Crop Production and Soil Management, by Joseph F. Cox. Pp. xxx+516. (New York : J. Wiley and Sons ; London : Chapman & Hall.) Price, 13*s.* 6*d.* net.
2. The Heritage of Cotton : The Fibre of two Worlds and Many Ages, by M. D. C. Crawford. (New York and London : G. P. Putnam's Sons.) Price, 21*s.* net.
3. Systematic Pomology, by U. P. Hedrick. Pp. xviii+488+24 plates. (New York : The Macmillan Co.) Price, 17*s.* net.
4. Report of the Fourth International Seed-Testing Congress. (London : H. M. Stationery Office.) Price, 11*s.* 6*d.*
5. Plants and Man : A Series of essays relating to the Botany of Ordinary Life, by F. O. Bower, Sc.D., LL.D., F.R.S. Pp. xii+365 (London : Macmillan & Co.) Price 14*s.* net.
6. Farm Friends and Foes, by J. H. Fabre. (London : T. Fisher Unwin, Ltd.) Price, 15*s.* net.

The following publications have been issued by the Imperial Department of Agriculture since our last issue :—

Memoirs.

1. The Quality and Yield of Tobacco as influenced by Manurial and other Operations, by J. N. Mukerji, B.A., B.Sc. (Chemical Series, Vol. VIII, No. 1.) Price, As. 8 or 9*d.*
2. Investigations on Indian Opium. No. 4—Further Experiments on the influence of Manures on the Yield and Morphine Content of the Latex of the Opium Poppy, by Harold E. Annett, D.Sc., F.I.C., M.S.E.A.C., and Har Dayal Singh, B.Sc.; No. 5—Experiments on Oil-content of the Seed of the Opium Poppy ; and No. 6—Studies on the Ash Constituents of Indian Opium, by Harold E. Annett, D.Sc., F.I.C., M.S.E.A.C., and M. N. Bose, M.A. (Chemical Series, Vol. VIII, Nos. 2-4.) Price, As. 8 or 10*d.*
3. A Contribution towards a Monograph of the Indian Coniopterygidæ (Neuroptera), by C. L. Withycombe, Ph.D., M.Sc., D.I.C.; Papers on Indian Tabanidæ and Some Observations on the Life-history and Habits of *Phycus brunneus*, Wied. (Family Therevidæ), by P. V. Isaac, B.A., M.Sc., D.I.C., F.E.S. (Entomological Series, Vol. IX, Nos. 1-3.) Price, Rs. 2-2 or 4*s.*
4. Nasal Granuloma in Cattle, by V. Krishnamurti Ayyar, I.V.S. (Veterinary Series, Vol. III, No. 6.) Price, Re. 1 or 1*s.* 6*d.*

List of Agricultural Publications in India from the 1st February to the 31st July, 1925.

No.	Title	Author	Where Published
	GENERAL AGRICULTURE		
1	*The Agricultural Journal of India*, Vol. XX, Parts II, III, and IV. Price, Re. 1-8 or 2*s.* per part. Annual Subscription, Rs. 6 or 9*s.* 6*d.*	Edited by the Agricultural Adviser to the Government of India.	Government of India Central Publication Branch, Calcutta.
2	Bud and Boll Shedding in Cotton. Pusa Agricultural Research Institute Bulletin No. 156. Price, As. 14 or 1*s.* 6*d.*	G. R. Hilson, B.Sc., V. Ramanatha Ayyar, L. Ag., and R. Chokkalingam Pillai, L. Ag.	Ditto
3	The Experimental Sullage Farm, Lyallpur. Pusa Agricultural Research Institute Bulletin No. 157. Price, As. 12 or 1*s.* 3*d.*	P. E. Lander, M.A., D.Sc., A.I.C., Agricultural Chemist, Punjab.	Ditto
4	New Fodder (Siloed *Shisham* Leaves) for Dairy Cows. Pusa Agricultural Research Institute Bulletin No. 158. Price, As. 6 or 8*d.*	P. E. Lander, M.A., D.Sc., A.I.C., Agricultural Chemist, Punjab, and Pandit Lal Chand Dharmani, L. Ag.	Ditto
5	Silage for Fodder in Western India. Bombay Department of Agriculture Bulletin No. 120. Price, As. 4.	E. J. Bruen, Live Stock Expert to the Government of Bombay, Poona.	Yeravda Prison Press
6	Further Investigations on Potato cultivation in Western India. Bombay Department of Agriculture Bulletin No. 121. Price, As. 6.	Harold H. Mann, D.Sc., Director of Agriculture, Bombay Presidency, and W. V. Joshi, B. Ag.	Ditto
7	Experiments with the automatic water Finder in the Trap Region of Western India. Bombay Department of Agriculture Bulletin No. 72 of 1915. Revised (1925). Price, As. 4.	Harold H. Mann, D.Sc., Director of Agriculture, Bombay Presidency, and D. L. Sahasrabuddhe, M.Ag., M.Sc, Ag. Agricultural Chemist to the Government of Bombay.	Ditto
8	Annual Report of the Department of Agriculture in the Bombay Presidency for the year 1923-24.	Issued by the Department of Agriculture, Bombay Presidency.	Ditto